JOURNAL of the WESTERN SOCIETY of ENGINEERS

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FEBRUARY PROGRAM

SUPT. McANDREWS TO SPEAK AT LUNCHEON

FOURTH ANNUAL MID-WINTER CONVOCATION

WASHINGTON AWARD FUND INCREASED

LIBRARY REPORT

AMENDMENT TO CONSTITUTION

PAPERS ON SLEEVE, BALL AND ROLLER BEARINGS

RELATION BETWEEN CAPACITY OF SEWERS AND THEIR COST AND FRONTAGE ASSESSMENT:

By S. A. Greeley, M. W. S. E.

PORT ADMINISTRATION, [illegible] Chambers

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PROGRAM

Monday January 4 7:00 P. M.

"MEASUREMENTS OF LARGE VOLUMES OF GAS"

M. E. Benisch, Plant Testing Engineer,
Peoples Gas Light & Coke Co., Chicago

Monday January 11 7:00 P. M.

"POWER FLOW IN ELECTRICAL MACHINES"

Dr. J. Slepian, Research Engineer,
Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

Monday January 18 7:00 P. M.

"ECONOMICS OF GRADE REDUCTION VS. REDUCTION IN MILEAGE"

Chas. A. Morse, Past Pres., W. S. E., Chief Engineer,
C. R. I. & P. R. R. Co., Chicago

Friday January 22 1:30 P. M.

Excursion to Automatic Electric Mfg. Co.,
1027 W. Van Buren Street

Monday January 25 7:00 P. M.

"CONTINUING THE ENGINEER'S EDUCATION"

Several prominent speakers under the auspices of the
Junior Engineers of the Society.

January 26-29

Midwest Power Conference—See program on page 165

Monday February 1 7:00 P. M.

"THE SANITARY DISTRICT OF CHICAGO"

Several speakers covering the general scope and important
details of the sanitary engineering program for Chicago.

Monday February 8 7:00 P. M.

"ILLUMINATION AND THE INDUSTRIES"

W. E. Conley, Illuminating Engineer,
National Lamp Works of G. E. Co., Cleveland

Monday February 15 7:00 P. M.

"CONSTRUCTION FEATURES OF THE DELAWARE RIVER BRIDGE"

Ralph Modjeski, Past Pres., W. S. E., Chief Engineer,
Delaware River Bridge Commission

Tuesday February 23 7:00 P. M.

"EXPLOSIVES IN INDUSTRY"

John E. Hatt, E. I. duPont de Nemours & Co., Chicago

JOURNAL OF THE
WESTERN SOCIETY OF ENGINEERS

Volume XXX JANUARY, 1925 Number 1

BUSY MONTH IN PROSPECT

Although February is the shortest month of the year it promises to be the busiest for the Western Society of Engineers. Besides four teachnical meetings we have two metings of the Young Men's Forum, one luncheon, one excursion and the mid-winter convocation which includes four daytime meetings and a diner meeting on February 20. Not only is the program heavy on account of the number of events scheduled but every one of them is of the highest order. With a membership embracing as many different classes as are found in the Western Society of Engineers, it is necessary that our program cover a wide field of activities but it is noticeable that every one of the subjects offered in February is of broad general appeal.

What Is a Patent?

The first meeting of the month on Monday, February 2, is to be addressed by William O. Belt, Patent Attorney and President of the Patent Law Association of Chicago, who will speak on the general subject of patents. Every engineer encounters patented articles in one way or another in his work very frequently and it is obvious that he should understand the subject well. However, it is safe to say that there is a great deal of misconception about patents. Mr. Belt is going to give a non-technical lecture in which he will explain what a patent is, how it is secured, what it will do and what it will not do and the rights of the owner thereof. Mr. Belt is well qualified to speak on this subject and is an entertaining speaker. He is able to take a subject ordinarily considered dry and make it interesting to listen to.

Standard Engineering Contracts

Monday, February 9, will be devoted to engineering contracts which is another subject that engineers encounter in their daily work. There is a little history connected with this meeting. About three years ago the War Department called a conference of various construction interests at Washington, D. C., to consider the matter of engineering contracts. It had found in the days of feverish activity of construction during the war that there were over two hundred different forms of contract in use, covering general building construction. After peac e was declared the War Department set about to remedy this situation as it was recognized that it involved an enormous economic loss. Accordingly a conference of seven national o-ganizations of professional engineers and constructors and the Western Society of Engineers was called in Washington, D. C. Onward Bates Past President, W. S. E., was made honorary chairman of the permanent committee which was formed at this conference to draw up and submit a standard form of contract for engineering construction and also for construction of buildings. J. D'Esposito was chairman of the local committee appointed by the Western Society of Engineers to make its recommendation. John W. Cowper, M. W. S. E., was chairman of the general committee.

A tentative draft of a proposed standard contract was drawn up and submitted to the contributing bodies for criticism. The contract was then revised and submitted a second time for criticism. After the various differences were adjusted it was submitted a third time and now has the approval of the representatives of the construction industry throughout the United States.

There has been no formal discussion of

the general form of contract before the Western Society of Engineers until this time. J. D'Esposito and Richard E. Schmidt will lead the discussion, setting forth the considerations which lead to the adoption of each of the features incorporated in the general conditions.

Progress in Aviation

The meeting on Monday, February 16, is expected to be devoted to the subject of aviation. This will be a joint meeting with the Chicago Section, American Sociat yof Mechanical Engineers. It has been hoped that we could have one of the American aviators who made the famous flight around the world as the principal speaker on that evening but there has been some little difficulty in making all the arrangements so it cannot be definitely announced who the speaker will be.

Street Paving in Chicago

Chicago paving practice will be the subject of the February 23 meeting at which John B. Hittell, M. W. S. E., Chief Street Engineer, Board of Local Improvements and A. J. Schafmayer, M. W. S. E., Division Engineer, Board of Local Improvements, will be the speakers. In a city the size of Chicago, every kind of pavement is trid out for different classes of service. The experience gained in this work shows the kind of paving that must be used for different kinds of work if satisfaction is to be secured. City engineers from all over the country come to Chicago to secure information which will enable them to solve their own paving problems.

The men who are to speak at this meeting are engineers who have had years of experience in that kind of work. The paper that is being prepared for this meeting is a history of the development of the practice of street paving.

Friday the Thirteenth

Friday, the thirteenth, may be unlucky for some people but it is a lucky day for the Western Society of Engineers for the reason that we are to have a very interesting speaker for our noonday luncheon at that time. W. G. McAndrew, Superintendent of Public Schools of the City of Chicago is to be our speaker and has chosen as his subject, "Your School." That subject shows just how Superintendent McAndrew feels about his position as Superintenden t of Schools. That is that he is working for the citizens of Chicago and for the best interests of their children. Frank D. Chase, Chairman of the Noonday Lunch Committee writes as follows, after his interview with Mr. McAndrew:

"This talk, from what Mr. McAndrew told me, is going to be candid—not candied and will be good for our souls. The man who misses this will be unlucky, indeed. Education in Chicago calls for ability, not politics, to conduct what is literally an enormous organization. This interesting address will be given at the Auditorium Hotel, after the luncheon at 12:15 p. m., Friday, February 13.

Let's all go. It will be well worth while."

Durgin to Speak on Simplified Practice

The Young Men's Forum has planned two meetings of special interest not only to the younger men registered in it but to all members of the Society interested in their progress in the profession.

William A. Durgin, M. W. S. E., Director of Public Relations of the Commonwealth Edison Co. will tell the Forum on February 11, "What Secretary Hoover Considers a Prime Need in Business."

Associated with the Edison Company for many years, he was drafter for service as chief of the Division of Simplified Practice of the Bureau of Standards at Washington, when Herbert Hoover took charge of the Department of Commerce.

Simplified practice as conceived, developed and propogated by Hoover is a very different thing from standardization. He keenly appreciated that the American public would be antagonized by a Prussianistic conception of standardization as meaning a world in which every object was of uniform design and identical in detail.

Simplified practice as preached by Hoover means simply the elimination of absolutely unnecessary sizes and types that are cluttering up the stocks of the nation,

and which account for less than 20 per cent of all the sales.

This work grew out of the survey of preventable waste in industry by prominent engineers made at the suggestion of Hoover, when he was president of the Federated American Engineering Societies.

Mr. Durgin, through his close association with this work, gives concrete examples of increased volume and profit through elimination of odd and rarely-called-for sizes and varieties of even the most common article in every day use. By means of slides and a most interesting presentation of the facts, Mr. Durgin will give us something to think about. Mark your calendar for February 11 now.

Can You Describe What You See?

We are all trained to observe technical details in our professional work, but can we pick out the essential features—the "news" items—and tell of them in an interesting and accurate manner?

W. S. Lacher, M. W. S. E., managing editor of **Railway Engineering and Maintenance** and western engineering editor of the **Railway Age,** will tell the Young Men's Forum, "How a construction project story is written," on February 25.

Writing is a fascinating and pleasure giving task, in which all who are progressing must indulge—in letters, reports, technical literature and news stories. Here is an opportunity to learn at first hand, how a story is covered by a man in the writing business.

Mr. Lacher will use as his illustration an account of the field and office work involved in writing a story of the longest railroad tunnel in America.

The Moffat Tunnel on the Denver & Salt Lake Railroad in Colorado is being driven six miles through the continental divide to eliminate a tortuous climb of 30 miles over Rollins Pass. This existing surface line not only involves 4 per cent grades with an exceedingly winding alignment but a climb to elevation 11,660 with heavy snow falls and frequent blizzards to fight the greater part of the year.

The late David Moffat conceived this project over 17 years ago but it has been a difficult task to find a workable method of financing. It is now being financed and built by a "Tunnel District" commission similar in nature to our "Sanitary District."

With its unusual setting, financial problem, size and scope and construction difficulties (the portals although only 6 miles apart are separated 30 miles by rail and 75 by highway) it offered a real problem to the reporter. Mr. Lacher will describe the preliminary arrangements, the field observations and office work which were necessary in writing this story.

There is always a demand for technical men who can write. Come out to hear how it is done.

Section Officers to Be Nominated

The By-Laws of the Western Society of Engineers provide that members of the Executive Committee of each section shall be nominated at next to the last meeting scheduled to be held by the section in the fiscal year and elected at the last meeting. Our program has now advanced to the point where some of the sections are nearing the end of their schedule and nominations are being prepared in accordance with constitutional requirements. Following is the table of dates showing time when nominations are to be presented and elections held.

Section	Nomination	Election
T. T. & R.	Feb. 2	Apr. 6
Mech.	Feb. 16	Apr. 13
H. S. & M.	Feb. 23	Apr. 20
Ill.	Mar. 2	Apr. 27
R. R.	Mar. 8	May 11
Gas	Mar. 16	May 11
Elect.	Mar. 23	May 18
B. & S.	Mar. 30	May 25

The by-laws further provides that additional nominations may be made by petition signed by ten members of a section if received by the Secretary two weeks prior to the election.

E. F. Manson, A. W. S. E., Division Engineer of the C. R. I. & P. Ry. Co., at Fairbury, Nebraska, has been transferred to the position of Division Engineer of the Missouri Division of the same railroad with headquarters at Trenton, Missouri.

Looking Into the Future

"Planning Chicago's Development" will be the subject of the Fourth Annual Mid-winter Convocation of the Society to be held February 19 and 20. The subject will be treated under four main heads or divisions in each of which a crisis faces the city right now. Upon the immediate solution of these questions depends the successful growth of the Chicago region as an industrial metropolis.

Critical situations exist in sanitation and water supply, local transportation, rail and water terminals and public welfare. Chicago has dreams of becoming a city of ten million people and the growth of the city during the past generation indicates that this may develope. If so, it is obvious that the development of the city must be most carefully planned.

It is proposed to hold technical meetings both morning and afternoon of February 19 and 20 and conclude the series with a dinner meeting the evening of the 20th.

These are subjects that have not attracted wide public notice because they are not spectacular but the fact remains that they should be given the most careful consideration. Who is better qualified to analyze them and suggest plans than the engineering profession? It is with this thought in mind that the Convocation Committee chose this subject for our program this year. The committee in charge consists of F. K. Copeland, chairman; R. F. Schuchardt, vice-chairman; W. W. DeBerard, C. L. Post, L. R. Howson, Jacob L. Crane, Jr., H. L. Kellogg, Major Rufus W. Putnam. Under the guidance of this committee, the sub-committees have prepared the following program:

Sanitation and water supply will be presented on Thursday morning, February 19, at 10:00 a. m., under the direction of L. R. Howson, chairman. There will be two papers which will give a complete picture of the situation. John Ericson, M. W. S. E., City Engineer of Chicago, will give a paper on the water supply of Chicago. Mr. Ericson has presented several papers before the Western Society of Engineers and we know that when he agrees to do so, his subject will be well handled. George W. Fuller, famous consulting sanitary engineer and chairman of the Engineering Board of Review, Sanitary District of Chicago, will read a paper on the sanitary situation. Mr. Fuller was retained as Consulting Engineer of the Sanitary District several years ago and is intimately acquainted with its problems and plans.

A buffet lunch will be served in the Society rooms at noon so that the session can be resumed promptly at 2:00 p. m.

In the afternoon of Thursday, February 19, the public welfare division of which Jacob L. Crane, Jr., is chairman, will present four short papers on topics which are recognized as being important but which are difficult to reduce to exact figures. Eugene Lies, Chicago representative of the Playground and Recreation Association of America, will read a paper on Public Recreation. This will be followed by a paper on Zoning and Housing by C. B. Ball of the Health Department, City of Chicago. Public Safety will be discussed by Sidney J. Williams, Chief Engineer, National Safety Council and Social Significance of Superpower will be discussed by R. F. Schuchardt, Electrical Engineer, Commonwealth Edison Company. The meeting will adjourn at 4:00 p. m.

Beginning 10 a. m., Friday, Feb. 20, local transportation will be taken up by the division of which H. L. Kellogg is chairman. The first paper will be "Urban Transportation, Rapid Transit and Surface Lines," by C. V. Weston, Consulting Engineer, Chicago Surface Lines. George A. Quinlan, Superintendent of Highways, Cook County, will read a paper on "Vehicular Traffic in Chicago and Cook County." Mr. Quinlan recently had charge of the extensive traffic surveys of Cook County, conducted in co-operation with the United States Department of Agriculture, Bureau of Public Roads. His investigation will be the basis on which recommendations for the development of Cook County highways will be based. This paper will be followed by one on "Suburban Electric and Steam Railway Traffic," by B. J. Fallon, General Manager, Chicago Rapid Transit Lines. This session will cover the passenger transportation

problem of Chicago and Cook County in its various details.

The question of rail and water terminals is one of the most important from the commercial or industrial standpoint. Major Rufus W. Putnam is chairman of the sub-committee which has this division in charge and will present the following program. Major Putnam who is an authority on terminal planning will read a paper on the fundamentals of terminal planning. Following this will be a paper on "Railborn Commerce in the Chicago Region and Its Requirements," by E. H. Lee. Vice-president and General Manager. Chicago and Western Indiana Railroad. The last paper on the program will be by E. O. Griffenhagen, Consulting Engineer, who has recently made an investigation of the subject, "Waterborn Commerce in the Chicago Region and Its Requirements."

The Convocation will culminate in a dinner to be given Friday evening at which time there will be an address by a prominent speaker to be announced later. At this time there will be a resume of the Convocation and a report of conclusions recommended for the development of the Chicago of the future.

It will be recalled that last year the study of local transportation resulted in a constructive report containing a number of recommendations some of which have already been acted upon while others are being investigated. It is reasonable to suppose that a similar report may result from this Convocation.

Major Rufus W. Putnam, Third Vice-President W. S. E. was awarded the Arthur M. Wellington prize at the annual meeting of the American Society of Civil Engineers in New York, January 21, for his paper on "Modern Rail and Water Terminals with Reference to Chicago," which was presented at the Chicago convention in 1923. Maj. Putnam is chairman of our Waterways Committee and also of the sub committee which will present the rail and water terminal section of the Mid-winter Convocation, February 19 to 20.

Studies Chicago Street Lighting

A matter which concerns every resident of Chicago was discussed at our meeting on December 22 namely, that of lighting Chicago's streets. There were four papers presented followed by a lively discussion which brought out many points of interest to be considered in planning a street lighting system.

The first on the program was Joseph C. Hail, Deputy Commissioner of Gas and Electricity of Chicago, who gave a very complete description of methods for lighting residence streets. No small part of the work of installing the lighting system is the laying of cables and building foundations for the lamp standards. Mr. Hail exhibited two reels of motion picture films showing the operation of building the concrete foundations and erecting the lamp posts ready for the installation of the fixtures. His lantern slides showed the fundamental scheme upon which the lighting system is based, emphasizing the essential factors. In Chicago, it is recognized that there are two important points to be considered in every block, namely the street intersection and the alley entrance. In districts which are not laid out on the alley scheme no attention is paid to this factor. If it were not for the necessity of illuminating the entrance to the alley, illumination in the center of the block could be calculated to secure whatever intensity is desired in the regions which are not considered critical.

Highway lighting was discussed by R. J. Malcomson of the Public Service Company of Northern Illinois, as one of the developments which is bound to come into larger use in the next few years. He pointed out the difference in the requirements of highway lighting as compared with ordinary city street lighting. Because of the greater areas to be covered it is necessary to eliminate every possible item of expense in construction and maintenance. The requirements are also somewhat different because the lights must be located out of the line of vision of automobile drivers which indicates the necessity for high poles. The necessity for reducing cost requires much wider spacing

than would be permissible in city street lighting. He estimates that the cost of properly lighting a highway to be about one-tenth the cost of construction of concrete pavement in Cook County. By the expenditure of this additional ten per cent the highways can be made useful throughout the twenty-four hours of the day so that heavy freight traffic can be moved at night when the roads are not congested with passenger traffic.

Orville F. Haas, Engineer of the National Lamp Works of General Electric Company, Nela Park, Cleveland, next read a very instructive paper on "The Need for Better Street Lighting." Mr. Haas urged the use of larger street lighting units with proper accessories to give the most efficient distribution of light so as to secure as high an intensity of illumination as possible.

L. A. S. Wood, Engineer of the Westinghouse Electric and Manufacturing Company, was unable to attend and present his paper on the lighting of Sheridan Road in Chicago but one of his associates discussed that subject in his place. He described some of the recent improvements made in street lighting units showing examples of refractor equipment and ornamental street lighting units.

Following the presentation of these papers there was a lively discussion which brought out many good features. A. J. Sweet, Consulting Illuminating Engineer, from Milwaukee, urged the use of units suspended from the center of the street instead of mounted on short poles at the side. Considerable economy of installation can be shown by this method as well as an increase in the mount of light delivered on the street surface.

Chicago Has World's Largest Pumping Plant

Loran D. Gayton, M. W. S. E., Engineer, Waterworks Design, City of Chicago, presented an excellent paper before the Society, Monday, December 29, on the new Western Avenue pumping station of the Chicago water works which is now in course of construction. Mr. Gayton handled his subject well, presenting first the picture of the Chicago water works showing the necessity for the new pumping station, then the studies made to determine the kind of equipment that would be used in the station, then the mechanical details of the equipment and then the heat balance or the forecast of conditions of operation that should exist when the station is put into service. This paper was well illustrated throughout with lantern slides showing the features of special interest.

It became necessary to build this station to supply a large area on the southwest part of the city which suffers from lack of water pressure which is at least partly due to the heavy requirements of the stock yards district. The new station is designed to serve an area of about nineteen square miles but will serve double that area if universal metering is adopted. Water is taken from Lake Michigan through a tunnel which was inspected by the members of the Western Society of Engineers on their first excursion of this year.

In selecting the equipment to be used exhaustive studies were made of centrifugal pumps driven by turbines centrifugal pumps driven by deisel engines, centrigal pumps driven by 12,000 volt motors and by 2,300 volt motors and of triple expansion pumping engines. Mr. Gayton gave the results of these studies on which the selection of centrifugal pumps driven through gears by steam turbines was based.

Mechanical facilities in the plant include coal-handling apparatus, ash-handling systems and modern boilers with superheaters furnishing steam at 300 pounds pressure with 200 degrees of super heat. In case of emergency two of the four boilers will carry the peak load of the station under permissible overload.

Particular attention was paid to the auxiliaries in this station to secure the highest possible economy of operation. Due consideration was also given to continuity of operation, some of the auxiliaries being driven electrically and others by steam as required by the heat balance which was very carefully worked out. So far as known this is the largest water works pumping plant in the world and the first one for which a complete heat balance was worked out in advance, the same as for a large central station.

Lubrication Problems

Lubrication was the subject of the first meeting held in January under the auspices of our Mechanical Section jointly with the Chicago Section, American Society of Mechanical Engineers. At this meeting J. A. Marland, Technical Manager, Vacuum Oil Co., Chicago, read a paper on the various kinds of lubrication service where oil is most suitable and C. L. Sonen, Factory Manager, Bassick Manufacturing Company, Chicago, read a paper describing those classes of service where grease is used.

Mr. Marland described some of the serious lubrication problems encountered in steel mills where the conditions are severe. Circulating systems providing for the repeated use of oil have overcome many of the difficulties encountered. Another innovation has been the use of the gear case or bath system where gears are encased in a housing which is filled with oil.

Cement mills present a difficult problem from a lubrication standpoint because of the amount of abrasive dust which penetrates into the bearings.

Special operating conditions have led to the development of types of bearings lubricated by grease which were described by Mr. Sonen. These bearings are familiar to many because of their use on automobiles. They have other application where this type of lubrication may be used satisfactorily. Locomotives and other heavy machinery offer a promising field.

Both of these addresses were liberally illustrated with examples taken from the experience of the speakers. There was a good discussion of practical experiences after the papers were read.

Members of the Student Branch of the Western Society of Engineers at Armour Institute have enjoyed an especially good program this fall. They are enthusiastic about the kind of meetings they have been having and propose to continue this sort of a program throughout the year. November 6, E. T. Howson, President of the Society and Western Editor of the Railway Age gave the students an inspiring address in which he included a number of hints that will be valuable to the students in their later life.

Chief Chemist Mohlman of the Sanitary District of Chicago, gave an interesting address on Sewage Disposal of the City of Chicago at the meeting held November 20.

Robert H. Ford, M. W. S. E. Assistant Chief Engineer, Chicago, Rock Island & Pacific Railway, spoke to the Student Branch, December 4, on "Success in Engineering." Mr. Ford has a large amount of sympathy for the young men in engineering and always brings them a message of encouragement. His address was much appreciated.

Waterproofing Is Important

Perhaps engineers who are not directly involved in the construction of bridges and viaducts do not realize the importance of waterproofing but to those men who do have it in charge, it is a most important matter. This was evident from the interest shown in the paper on "Waterproofing of Railroad Bridges" by G. A. Haggander, M. W. S. E., Bridge Engineer, C. B. & Q. Ry. Co., at our meeting, January 12, 1925.

Mr. Haggander has studied this subject for a great many years and has developed a complete set of specifications for this work. He included his specifications in the paper and then gave a very interesting history of the methods of waterproofing which he illustrated with a number of lantern slides.

It is interesting to note the developments that have taken place in the practice of waterproofing bridges and the studies that have been made of various failures as they occurred. It may be said now that practically the only trouble which is encountered is at the expansion joints. Mr. Haggander showed a number of different types of expansion joints which have been developed but they are not yet entirely satisfactory. Waterproofing around drainage outlets and at the edges of protected sections seems to be pretty well solved.

In the discussion following this paper there were a number of practical points brought out and some interesting descriptions of failures of waterproofing.

Causes and Products of Research

Engineers generally appreciate the importance of research as was evidenced by the close attention paid to Dr. Ernest De Witt Burton, President of the University of Chicago, at our noonday luncheon, Friday, January 16. There was a good attendance in spite of the unpleasant weather.

President Elmer T. Howson, in introducing the speaker called attention to the interest of the engineers and their close association with the universities where research is conducted.

Dr. Burton who chose for his subject, "Causes and Products of Research," said that on the common ground of citizenship men of all professions have a platform where all can meet to discuss problems of mutual interest. He pointed out that in the field of research tremendous advances have been made in the past generation. Only forty or fifty years ago, it was a word that was rarely heard. Not only the word but the thing that it represents is new.

Research might be defined as the search for the unknown. Men have always done this but only in recent years has the effort been organized.

It might be said that there are three causes for research, namely: human needs, human curiosity and a world capable of absorbing the results of research. Taking these up in the order named, Dr. Burton pointed out that the first need of man was hunger and that to satisfy this need he became a fisherman, a hunter or a farmer. To protect himself from the elements he became a builder of shelters. To satisfy the need to cross a river he became a builder of bridges or boats. To satisfy the other needs of the human race he has become the builder of the many devices which contribute so largely to the enjoyment of humanity today.

Human curiosity is the second great force which has promoted research. Man first looked at the stars and became curious to know about them so became an astrologer and then an astronomer. He dug in the earth and from the study of the rocks became a geologist. He met men of a different race who spoke a different language and from a study of their languages became a linguist. So it goes through all the range of sciences. James Watt noticed the lifting of the lid of a tea kettle and became curious to learn the power of steam. Benjamin Franklin conducted his famous experiment with the kite out of curiosity. There are thousands of other examples that might be given to illustrate the results of man's curiosity as to the forces of nature.

Modern research might be said to have four principal results, namely: the financial, physical, social and spiritual. The financial earning power of a man is now four times what it was a century ago, when measured in the ability to satisfy human needs. The great increase in the world's wealth is primarily due to research of one kind or another. Continued research has brought about tremendous physical results, such as the relief of physical ills, cure of disease and prevention of pestilence.

In the realm of the social science, results are less tangible but there are many who believe that unless research is carried into these fields including the study of sociology, economics, etc., the result of research in the physical sciences will lead to the destruction of the human race. We are just beginning to appreciate the result of research along spiritual lines and to recognize that human thinking controls the philosophy by which men regulate their whole lives. Just as research in astronomy helped in navigation, so research in philosophy is of tremendous value in regulating the relations of men.

Modern research may be said to be organized curiosity. It is best exemplified by the research laboratories of our large universities and industrial establishments where men trained in every field of science are searching for fundamental truth. Dr. Burton gave some examples from his own contact with Professor Michelson and other scientists at the University of Chicago. Professor Michelson's studies of light are regarded by scientists as being of the greatest importance. To some who might be inclined to ask what practical results would follow from these investigations, it is hinted that an entirely new method of surveying may be developed after the velocity of the travel of

light is determined with absolute accuracy. It is the hope of Professor Michelson that he will be able to determine the velocity at which light travels with a possible error of less than one mile per second.

Increases Washington Award Fund

One of the most encouraging things that has come to the officers and directors of the Western Society of Engineers in recent years is the action of Past-President, John W. Alvord, who has increased the endowment of the Washington Award. It was a total surprise to the Board of Direction to receive the following letter from Mr. Alvord at its meeting December 22, 1925'

"Mr. Elmer T. Howson, President,
Western Society of Engineers,
1736 Monadnock Block,
Chicago, Illinois.
Dear Sir:

"It has been a source of continued gratification to me that the Societies associated together in the Washington Award administered by the Western Society of Engineers should have so cordially approved and furthered the idea of annually indicating some engineer who had merited public attention for his work for the public good. The labor necessary to carry forward the Award by committee work and in annual ceremony has been considerable, and has been cordially and gratuitously given, but I think the necessary annual expenses must have outgrown the original endowment, which, as a pre-war project, was started on a somewhat modest scale.

"It appears to me that further addition to the endowment is both desirable and necessary in order that the presentation may not be hampered in any way. I take pleasure, therefore, for these reasons, in handing you herewith my check for $2,000.00 to be added to the original endowment but without restriction so that the Board of Trustees of the Western Society may, if ultimately necessary, use the fund in any way that seems to them wise and desirable. Cordially yours,

(Signed) JOHN W. ALVORD."

The president and secretary were instructed to acknowledge receipt of this gift nad to prepare and forward to Mr. Alvord a suitable resolution expressing the appreciation of the Society.

Accordingly the following resolution was prepared and a copy bearing the individual signatures of every member of the Board of Direction was forwarded to Mr. Alvord:

"WHEREAS: Mr. John W. Alvard, Founder of the Washington Award and a Past-President of the Western Society of Engineers has presented to the Society, two thousand dollars ($2,000.00) as an additional endowment.

BE IT RESOLVED, by the Board of Direction of the Western Society of Engineers, that in accepting the fund they express their appreciation of the gift and of the spirit that prompts it, as an indication of the interest of the donor in the advancement of the profession and the recognition of his fellow engineers, for their contributions to the progress of humanity."

In responses Mr. Alvord wrote as ollows:

My dear Mr. Howson:

"I thank you very much for your very kind and appreciative letter of December 31st, in connection with my increasing the endowment for the Washington Award. I very fully appreciate this letter, and shall prize it among my valued possessions.

"I also wish to express, through you, to the Board of Direction my appreciation of the Resolution which they passed on December 22nd, and the very delightful memento which the same took as a signed copy of the present Board of Direction. I shall cherish the copy of the Resolution as one of my valued mementos.

"With cordial best wishes for the success of the Society during the New Year, I am. Very truly yours,

(Signed) JOHN W. ALVORD."

Members May Purchase Library Books

To any one who may ask the question "Of what use is a library?" the report compiled by our librarian covering operations for the six months ending December 31, 1924, furnishes a most conclusive answer. We have always known that our library was doing good work and that it was busy all of the time but had no figures to answer specific questions. One question which sometimes arose was as to the amount of time devoted to reference work and how many questions were asked; what kinds of questions they were and whether they came from members or non-members.

A simple form of record was established by means of which it was easy to compile this information. The report shows that during this six months' period there were a total of 1143 reference questions asked of which 871 were answered completely; 42 answered in part; 43 referred to other sources of information and 238 on which partial information was found. These questions came from 509 members, 303 non-members and 291 whose connections were not determined. In the 115 days covered by this report there were a total of 2,875 visitors who made use of the library or an average of 25 per day. There were 194 telephone calls for information referred to the librarian and 10 requests by letter. Books loaned to members totaled 267 and there were 62 photostat copies of extracts from books or magazines furnished.

There have been 392 books aside from the special collections added to the library during this period. Special collections worthy of mention are the Lotholtz library, 450 volumes; the Stephens loan of 60 volumes on aeronautics, 35 volumes selected from J. W. Kendrick's library, 50 volumes from B. J. Arnold's collection and 12 volumes from H. A. Thomas.

The work of cataloging these as well as the unlisted books already on our shelves is a tremendous job. The cataloger has been busy since July and in the work of making up the catalog has gathered together about 250 duplicate volumes. These are being listed and will be offered to society members at greatly reduced prices. New books and latest editions are to be sold for half price while other volumes are to be sold at arbitrary prices set by the librarian according to the actual value of the edition.

There are 250 serial magazines and publications received in our library. Less than a quarter of these are bound because of the considerable expense involved.

Study Plumbing Code for Illinois

Efforts will be made at the coming session of the state legislature to secure passage of laws establishing a plumbing code for the State of Illinois to prescribe minimum requirements for plumbing in dwellings and similar buildings throughout the state. This is an outgrowth of the work done by the Department of Commerce at Washington through its standardization committee for the elimination of waste. One of the sub-committees appointed to investigate this subject prepared a most thorough report on plumbing for private and public buildings. Thomas F. Hanley, M. W. S. E., was a member of the sub-committee of five which prepared this report. It includes twenty recommended principles which are regarded as basic. The report comprises 260 pages and includes the results of extensive investigation conducted by the Bureau of Standards at Washington on all the elements that enter into the design and installation of proper plumbing.

A committee of representatives of the American Plumbers Association the Journeymen Plumbers Association, the Plumbing Inspectors and the Chief Sanitary Engineer of the Department of Health at Springfield held a conference last fall to consider the enactment of legislation for the adoption of a plumbing code for the State of Illinois. As a result of this conference it was suggested that a committee of sixteen be appointed to draw up the proposed legislation. This committee is to consist of five master plumbers, five journeymen plumbers, one member from the Illinois Society of Architects, one member from Institute of Architects, one member from

the Western Society of Engineers one member from the Chicago Association of Consulting Engineers, one member from the American Society of Sanitary Engineers and the chief sanitary engineer of the Department of Health at Springfield. This committee has been formed and will meet in Chicago in the near future. Thomas F. Hanley is to represent the Western Society of Engineers with the co-operation of Paul Hansen, Chairman of the Sub-Committee on Public Health, Public Affairs Committee, and Secretary Edgar S. Nethercut.

Any proposed legislation is to be submitted to the Board of Direction of the Western Society of Engineers before it receives the official sanction of the Society.

Propose Amendment to the Constitution

Amendments to the constitution relative to the qualifications of Student and Junior Members have been submitted to the Board by the Membership Committee and considered by the Amendments Committee. Persuant to the requirements of the constitution a petition has been prepared and presented to the Board at its meeting held January 19th. The Board ordered that this be prepared for letter ballot in accordance with the provisions of the constitution. It was not referred back to the Amendments Committee as they had already considered the matter and the chairman of the Amendments Committee reported that the majority were in favor of the amendments.

The following order of procedure is to be followed:

These amendments are to be presented at the regular meeting of the Society the first Monday in February, February 2nd. This presentation will be verbal.

Copies of the proposed amendments are to be mailed to the Corporate Members not later than fifteen days prior to the first meeting in March. This means not later than February 17th.

The proposed amendments are the regular order of business for discussion and amendment at the first meeting of the Society in March, (March 2nd.)

These amendments are to be submitted for a letter ballot by March 9th and included will be the proposed amendment, a ballot, a ballot envelope and a signature envelope. The polls will close and the ballots will be counted on April 1st.

The tellers will report to the Board of Direction at the April meeting of the Board.

The amendments, if carried, will be in effect the date of the Annual Meeting, June 3rd.

Offers Coal Storage Report to Members

Members of the Western Society of Engineers are extended the privilege of securing copies of the report by the American Engineering Council on "Storage of Coal" at reduced rates the same as granted to members of societies comprising the council.

It will be recalled that early in the spring of 1923 the American Engineering Council established a committee to study and report on the storage of coal. This committee of twelve engineers from all over the country was headed by W. L. Abbott, Past President, W. S. E., as chairman. Edgar S. Nethercut, Secretary of the Society was appointed representative of the Chicago District. The committee after a year of conscientious study for which there was developed a field organization of eighty-three sub-committees comprising 400 individual engineers, brought in a report which is published in book form in a volume of 400 pages. The report presents the findings, conclusions and recommendations of the committee as to (1) production and distribution of coal in the United States; (2) extent of the practice of storing coal; (3) methods and equipment of storage plants and physical and operating problems involved; (4) coal required by localities and advantageous points of storage; (5) transportation problems; (6) cost of installing and maintaining coal-handling and storage equipment; (7) cost of actual storage including problems of financing, insuring and taxing.

Special divisions of the subject are treated in chapters devoted to deterioration and spontaneous combustion, relation of

transportation to storage, storage of coal at the head of the Great Lakes, storage at tidewater and by government departments, location of storage plants, storage equipment, cost of installing and maintaining storage equipment, insuring, taxing and financing coal in storage, anthracite storage and local problems. The report is elaborate and well illustrated; being supported in every detail by careful investigation of all points about which there is any doubt.

Members of the Western Society of Engineers may secure copies of this volume at $3.00 each by mailing the order coupon printed herewith to the executive offices of the American Engineering Council, 26 Jackson Place, Washington, D. C. The regular price of the book to the public is $5.00. The coupon should be filled in with the member's name in the space indicated, showing that he is a member of this Society which entitles him to receive the book at reduced price.

Coupon

American Engineering Council
26 Jackson Place, Washington, D. C.

I enclose $3.00 for which please send me postpaid a copy of Industrial Coal, a report of the American Engineering Council.

Name ....
(Please print)

Address ....

City.............................. State..................

Member ....

The following members of the Western Society were elected to hold office in the Chicago Association of Commerce for 1925 at the annual election held December 10. For Vice President, Industrial Development and Public Improvemnets, Robert Isham Randolph, Secretary, Randolph-Perkins Company; for Directors, A. R. Bone, General Commercial Superintendent, Illinois Bell Telephone Company and Blaine S. Smith, General Sales Manager, Universal Portland Cement Company.

Circulates Power Test Codes

Continuing its program of establishing standard codes for testing of all sorts of power apparatus, the American Society of Mechanical Engineers has circulated preliminary copies of codes for testing solid fuels, speed-responsive governors and gas producers. These were presented at a public hearing Tuesday, December 2, at the annual meeting of that society in New York. Written discussion may be submitted to the Power Test Codes Committee for consideration before the codes are formally adopted. Copies of these codes will be found in the Secretary's office or in the library.

Albert L. Arenberg, M. W. S. E., has resigned his position as Manager of the Lighting Division of the Central Electric Company, with whom he has been associated for the last eleven years. His plans for the future are not yet definitely decided. He has taken an active part in engineering organizations and was largely responsible for the formation of an illuminating Engineering Section in the Western Society of Engineers.

A. L. Webster, M. W. S. E., of Wheaton, Illinois, was elected President of the Illinois Society of Engineers at the annual meeting held at the Great Northern Hotel in Chicago, January 14 to 16. E. E. R. Tratman, M. W. S. E., was president last year and at the close of this meeting was presented with a fine gold watch as a token of appreciation of his 21 years of service as secretary prior to his election as president of the society. Prof. A. N. Talbot, M. W. S. E., made the presentation.

This meeting was attended by over two hundred engineers mostly interested in municipal work throughout the State of Illinois. The technical sessions were devoted to water works, sewerage, survey and mechanical, mining and electrical engineering. There was a good discussion of each of the papers presented. A considerable number of the members of this society rae also members of the Western Society of Engineers.

J. J. Kirk, M. W. S. E., Chairman of the Illuminating Section of the Society has left the lighting division of the Commonwealth Edison Company to become manager of the Chicago office of the Pittsburg Reflector Company.

The Illniois Central R. R. Co. announced a list of promotions January 28 which includes several members of the society. F. L. Thompson, Chief Engineer becomes Vice President in charge of terminal improvement, filling the vacancy caused by the death of A. Stuart Baldwin, Past President W. S. E. A. F. Blaess, formerly Engineer of Maintenance of Way becomes Chief Engineer and L. H. Bond, formerly Assistant Engineer, Maintenance of Way becomes Engineer of that department. Needless to say the congratulations of their many friends in the society will be extended to these men who have won their promotions through years of service.

H. R. Safford, M. W. S. E., Vice President C. B. & Q. R. R. Co., has been made Executive Vice President of the International & Great Northern R. R. and the Gulf Coast Lines. He will be located in Houston, Tex., where he will be the resident executive of those lines. Mr. Safford was made assistant to the President in 1920, at the end of the period of government control becoming vice president soon afterwards. He has taken part in many of the activities of the society and the Illinois Section Am. Soc. E. E.

At the annual meeting of the Association of American State Geologists held in Ithaca, New York, December 29 to 31, the following officers were elected for 1925: President, Wilbur A. Nelson, State Geologist of Tennessee; Secretary, M. M. Leighton, M. W. S. E. State Geologist of Illinois; Member of Executive Committee, E. W. Matthews, State Geologist of Maryland. The Association voted to send a memorial to the President of the United States requesting a liberal support to scientific work. The memorial was presented in person by the new president of the Association and was favorably received.

APPLICATIONS FOR MEMBERSHIP

Members of the Society can be of great service if they will make a practice of examining the list of applicants published herewith and promptly notifying the Membership Committee or the Secretary regarding the qualifications of any of those whose names appear on the list. The Society desires to extend its membership and receive those engineers who have the proper qualifications and wish to participate in its activities.

No.	Name	Address
527—1924	Leo L. Michuda	11127 Lowe Ave., Chicago, Ill.
528	Grover O. Melby	1745 Merrimac Ave., Chicago, Ill.
529	Nellis J. Wagner	Box 1, Argo, Ill.
530	Clifford E. Ives	1304 Monadnock Block, Chicago, Ill.
531	Russell C. Kinsman	Box 271, Villa Park, Ill.
532	Harold W. Munday (Transfer)	1218 Elmdale Ave., Chicago, Ill.
533	Max L. Loewenberg (Transfer)	111 W. Monroe St., Chicago, Ill.
534	Leo Krumdieck (Transfer)	3654 S. Robey St., Chicago, Ill.
535	Howard E. Norton	614 Central Ave., Wilmette, Ill.
536	Samuel R. Willey	2053 E. 68th St., Chicago, Ill.
537	Ralph L. Ward	825 Ayars Place, Evanston, Ill.
538	Richard H. V. Shaw	Bldg. Dept. Ill. Central R. R., Chicago, Ill.
539	Samuel Deutsch	4454 N. Albany Ave., Chicago, Ill.
540	M. F. Nilson	Y. M. C. A., S. Wabash Ave., Chicago, Ill.
541	Harry M. Paetow	1537 W. 59th St., Chicago, Ill.
542	Wm. M. Nichols	Box 183, Angola, Ind.
543	J. Lyell Clarke	1524 E. 61st St., Chicago, Ill.
544	L. V. Castiglione	925 S. Wenonah Ave., Oak Park, Ill.

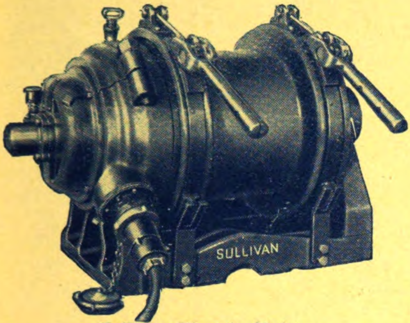
APPLICATIONS FOR MEMBERSHIP—Continued

545	E. M. Goodman (Transfer)	1719 Ridge Ave., Evanston, Ill.
546	Charles Singman	1425 N. Rockwell St., Chicago, Ill.
547	Edgar F. Osius	301 N. Mason Ave., Chicago, Ill.
549	Adrian A. Purvis	301 N. Humphrey Ave., Oak Park, Ill.
549	Fletcher W. Pearce	6444 Ellis Ave., Chicago, Ill.
550	Axel O. Jansson	2035 Leland Ave., Chicago, Ill.
551	William L. Kelly	704 W. Marquette Rd., Chicago, Ill.
552	Earl R. Geiger	3643 W. 65th St., Chicago, Ill.
553	Walter J. Giryotas	5964 W. Adams St., Chicago, Ill.
554	Anton S. Rosing	2125 Lunt Ave., Chicago, Ill.
555	John L. Oberly	4546 Sheridan Rd., Chicago, Ill.
556	Joseph H. Carr	7639 Eastlake Terrace, Chicago, Ill.
557	Frank W. Leske	4954 Huron St., Chicago, Ill.
558	Magnus Gundersen	2844 Logan Blvd., Chicago, Ill.
559	Orin H. Taylor	B. of Loc. Imp. City of Chicago

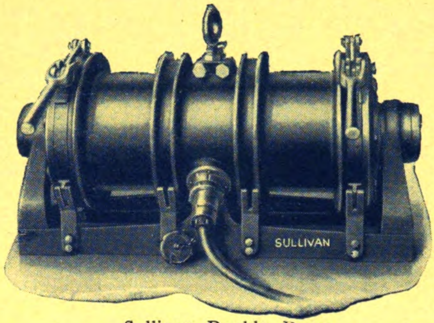
NEW MEMBERS

The following were elected to membership in the grade indicated by the Board of Direction at its meeting, December 22, 1924:

No.	Name	Address	Grade
188—1924	Clifford S. Sharp	201 S. West St., Angola, Ind.	Student
189	Rodney Whitt	419 S. Darling St., Angola, Ind.	Student
258	Raphael Torres	P. O. Box 225, Angola, Ind.	Student
259	Eugene F. Forelle	313 E. South St., Angola, Ind.	Student
260	Wayne S. Saxton	412 W. Gilmore St., Angola, Ind.	Student
501	Charles L. Hutchinson	413 S. College St., Angola, Ind.	Student
502	Pedro Guevara, Jr.	Box 177, Angola, Ind.	Student
503	Clyde M. Etter	613 W. Pleasant St., Angola, Ind.	Student
505	Chas. E. Wendnagel	4526 Greenwood Ave., Chicago, Ill.	Junior
503	Theodore S. Schaefer	3430 Schubert Ave., Chicago, Ill.	Student
507	Edwin A. Janssen	821 Lyman Ave., Oak Park, Ill.	Student
508	William J. Dixon	8011 Constance Ave., Chicago, Ill.	Student
509	Edward H. Marhoefer, Jr.	6739 S. Jeffrey Ave., Chicago, Ill.	Student
510	William E. Downes, Jr.	6212 Eberhart Ave., Chicago, Ill.	Student
511	Walter H. Bodnar	2135 Haddon Ave., Chicago, Ill.	Student
512	Alexander Rasmusen	6337 Ada St., Chicago, Ill.	Student
513	Louis W. Chatroop, Jr.	1249 Addison St., Chicago, Ill.	Student
514	Charles M. Nelson	1316 Belle Plaine Ave., Chicago, Ill.	Student
517	Floyd T. Bolton	900 W. Maumee St., Angola, Ind.	Student
519	Frank L. Prescott	200 N. California Ave., Chicago, Ill.	Junior
520	William G. Wood	6358 S. Sangamon St., Chicago, Ill.	Junior
523	Hernan Perez (Transfer)	Merida, Yucatan, Mexico	Junior
525	Henry S. Wolfe	304 S. Washington St., Angola, Ind.	Student
526	John L. Cameron	Box 178, Angola, Ind.	Student
448	Earle M. Brydon	1900 Sherman Ave., Chicago, Ill.	Junior
476	James I. Mitchell	1142 Noyes St., Evanston, Ill.	Junior
496	James W. Hood	1900 Sherman Ave., Evanston, Ill.	Junior
497	Lloyd R. Quayle, (Transfer)	38 Crescent Pl., Wilmette, Ill.	Student
498	Henry M. Terry	6650 Stewart Ave., Chicago, Ill.	Junior
499	Hugh G. Bersie, (Transfer)	532 Hinman Ave., Evanston, Ill.	Associate
500	William I. Brown	3301 Oak Park Ave., Berwyn, Ill.	Junior
504	Edwin C. Knuth (Transfer)	1331 28th St., Milwaukee, Wis.	Member
515	John A. Dunne	4818 Calumet Ave., Chicago, Ill.	Associate
522	R. F. Huxman	863 Colfax Ave., Benton Harbor, Mich.	Mem.
367	Lewis S. Jett, (Transfer)	601 W. Maumee St., Angola, Ind.	Associate
524	Edward Walker, Jr., (Transfer)	163 Cherry St., Battle Creek, Mich.	Associate



Sullivan Electric Hoist,
Single Drum



Sullivan Double Drum
Electric Hoist

A New Electric Hoist

(Portable)

Sullivan engineers have designed a new portable hoist, electric motor driven. It is similar in power, size and adaptability to the Sullivan "Turbinair" Hoists which have become so popular, and both single and double drum models are available.

Sullivan Electric Hoists have 6½ H. P. motor, mounted in a tight casing *inside the drum.* Reduction gears and bearings are enclosed and splash oiled. Ball and roller bearings throughout.
You can hoist a ton vertically on single line, or pull a 50-ton car on level track. The double drum hoist is compact and easy to handle for two rope jobs such as scraper loading, or boom derricks or car spotting. If you want to reduce your light hoisting and haulage costs, try these new electric units.

Electric Hoist Dimensions

	1-Drum	2-Drum
Length, inches	29	38
Width, inches	15	15
Height, inches	19¼	19¼
Drums, length, inches	8¼	6¼
Drums, diameter, inches	11⅛	11⅛
H. P.	6½	6½
Capacity, lbs.	2000*	2000*
Speed at Max. Load, ft. per Min.	110	110‡
Drum Rope Capacity, ft. each	500	250
Weight, pounds	450	780

* For vertical lift.
‡ Tailrope drum, 160 ft.

Catalogue 2076-E

SULLIVAN
MACHINERY COMPANY
122 So. Michigan Ave. Chicago.

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JOURNAL OF THE
WESTERN SOCIETY OF ENGINEERS

Volume XXX FEBRUARY, 1925 Number 2

WHAT IS COMING IN MARCH

The well established custom of the Western Society to hold its technical meetings on Monday evenings is pretty well violated in the month of March, for several very good reasons. The second meeting of the month is changed to Tuesday night so that visiting members of the A. R. E. A. may have an opportunity to attend and hear the description of the new Illinois Central Terminal. The next meeting is changed to Tuesday night to permit visiting members of the Illinois Gas Association who will be in Chicago that week, to attend. The fourth meeting is to be held in Fullerton Hall which could not be secured on Monday. This leaves only the first and last meetings to be held on Monday night.

The new Illinois Central Railroad Terminal in Chicago has been under discussion for a number of years. The plans for it are practically complete except for a few points which are not yet definitely settled. Building this new Terminal has required the entire rebuilding of the Illinois Central Line for a distance of nearly thirty miles to accomodate the heavy suburban traffic. This will be the first of Chicago's terminals to be operated electrically. D. J. Brumley, M. W. S. E., Chief Engineer of Chicago Terminal Improvements, I. C. R. R. is to be the speaker, on the evening of March 10th. Mr. Brumley will describe that portion of the work which is completed in addition to the parts of the work that are definitely decided at this time.

Tuesday, March 17, we are to have a paper by H. E. Bates, M. W. S. E., Assistant Chief Engineer, Peoples Gas Light & Coke Co., on "Some Engineering Features of a Modern Gas Plant." This is to be an engineering description of the operation of the world's second largest gas plant. We had a paper about three years ago, when the plant was being built, giving a description of its design. Now we are going to have an opportunity of hearing how the designs have worked out in practice. A large gas plant includes nearly all of the important elements in Mechanical engineering. To attain the best overall efficiency each of these elements must be worked out according to the best practice. This includes furnaces, boilers, steam engines, pumps, compressors, material handling equipment and many special devices peculiar to the needs of the gas business. It is intended that this paper will analyze the methods in use and show the results that have been obtained in service.

Meet In Fullerton Hall

It is anticipated that there will be an unusually large crowd in attendance at our meeting March 24th, which is to be held jointly with the Chicago Section, American Institute of Electrical Engineers at Fullerton Hall. The speaker of that evening is W. L. R. Emmett, Consulting Engineer, General Electric Co., Schenectady, N. Y., who is responsible for the much discussed mercury-vapor boiler and turbine system, by which an increase of about one half in the total thermal efficiency of a steam plant is secured.

Calculations indicate that it is possible to obtain an efficiency of 1 kwhr. per ten thousand b.t.u. There has been a medium sized unit of this kind in service at Hartford, Conn., for about a year, where efficiencies of about 12,000 b.t.u. are obtained. In general the sys-

tem includes a boiler in which mercury is vaporized and passed through a special turbine. On being condensed the mercury gives up its heat in a special boiler generating steam which operates a steam turbine driving a generator. Mr. Emmett will give a complete description of this system with illustrations.

The last meeting of the month will be held Monday, March 30 in our rooms. The speaker is A. S. Armstrong, Superintendent Bates & Rogers Construction Co., who will deliver a paper on "Construction of the White River Bridge, C. R. I. & P. R. R.) It was not the bridge itself which made this project so interesting as it is the usual steel type of railway bridge, having three fixed spans and one draw span, each about one hundred fifty feet long.

The approaches are unusually long, timber trestles. When building the foundation, the builders encountered the foundation of an old bridge built in 1859 which caused them a great deal of trouble. This old foundation was at a point 45 ft. below the level of the water and had to be removed before the new one could be continued. It was a timber grillage filled with stone and was very troublesome to remove.

The river bank protection was unusually complicated and required some careful study.

CONVOCATION SHOWS CRITICAL SITUATIONS IN CHICAGO

The Fourth Annual Mid-Winter Convocation was the outstanding feature of the month of February. There were meetings held morning and afternoon of two days in our auditorium and a Dinner Meeting at the Hamilton Club, on the evening of the second day. The general subject of the Convocation was "Planning Chicago's Development." This subject was built up along the line of four general sub-divisions, each dealing with a critical situation, which confronts the logical development of the city.

The Convocation opened Thursday, February 19, at 10:00 a. m. with an address by President Elmer T. Howson, who briefly outlined the problems that have been taken up. This session was devoted to questions of Sanitation and Water Supply, the program being arranged by a subcommittee of which L. R. Howson was Chairman. John Ericson, (M. W. S. E.), City Engineer of Chicago, presented a paper on the "Water Supply of Chicago," which created a great deal of interest. Mr. Ericson published the latest figures and estimates of future growth of the water supply system of Chicago and upon these he predicted the enormous losses that will follow, if the water of Chicago is not placed on a meter basis. If the city does use meters, he said that in a short time the present operating deficit in the water department will be changed to a surplus, and that in a few years more it will be possible to reduce the rates to consumers and at the same time build filter plants. He pointed out that the time may soon come when it will be impossible to use sufficient chlorine in the City water to counteract the constantly increasing pollution. When this time comes there is no other way to secure a pure water, than by the installation of filter plants. Present installed capacity is sufficient to supply the city's needs until 1960, with a few minor alterations if meters are installed.

Mr. Ericson's suggestion to the Western Society of Engineers was that the filter plants be built at convenient points along the lake shore and combined with recreation piers. He presented a number of tentative studies showing how this could be done at comparatively small

cost and with no sacrifice in efficiency.

George W. Fuller, Chairman of the Engineering Board of Review, Sanitary District of Chicago, which has just recently completed its exhaustive report on the sanitary stiuation here, read a paper on the "Sewage Disposal Problem of Chicago," in which he outlined the design and growth of the present system and the local conditions that have developed. He described the building program proposed by the Sanitary District and the importance of considering the water supply of the City as a part of the Sanitary District problem. He said that the total lowering of the levels of the Lakes due to all causes has been about 31 inches. Chicago is responsible for only 6 inches of this, which can be restored by the proposed regulating works at the outlet of Lake Superior, Lake Erie and Lake Huron. Mr. Fuller here made the first public announcement of a recommendation that the President of the United States call together the principal parties interested, for a conference as the logical means of arriving at a conclusion satisfactory to all parties concerned.

A buffet luncheon was served to about 60 members and guests, who desired to remain for the afternoon session.

Matters of General Public Interest

Public Welfare was the subject of the Afternoon meeting, which was arranged by a subcommittee under the chairmanship of Jacob L. Crane, Jr. At this time there were four papers presented dealing with subjects which are of public interest but which do not fall in a particular classification. The first speaker was A. E. Gorman, Sanitary Engineer, Department of Public Health, City of Chicago who read a paper on "Public Health."

He pointed out the importance of adequate supervision over the water supply and stated that without more knowledge of the physical conditions effecting Public Health in Chicago it was difficult if not impossible to determine what steps should be taken. He recommended that a complete survey be made, covering all matters which enter into the question of Public Health, such as, pollution of the water supply, eradication of mosquitoes, and rats, supervision over housing conditions and measures to secure freedom from smoke and poisonous gases in the atmosphere.

C. B. Ball, Inspector, Department of Public Health, City of Chicago, read a paper on "Zoning and Housing" in which he described the general principles of our Zoning Ordinance and the benefits to be derived therefrom. He told how the housing conditions can be regulated and property values protected by proper restrictions on building. This matter is important from a health standpoint also, as such a system prevents over-crowding.

Sidney J. Williams, (M. W. S. E.) Chief Engineer, National Safety Council made some interesting statements about accident hazards in Cook County which were well discussed. He pointed out that now the accident problem is on our streets. Of the total accidents on our streets, the number occurring on the boulevards and through streets is much less in proportion to the amount of traffic than those occuring on the so-called side streets. About 90 per cent of the persons injured by automobiles are pedestrians. This points to a serious problem in street traffic regulation, which is capable of solution by careful study and observation.

R. F. Schuchardt, (M. W. S. E.) described the development possible under the so-called superpower system. With adequate power available at any point within the metropolitan area, it is possible to locate factories at points where full advantage can be taken of the improved shipping facilities, location on waterways or at terminals, proximity to labor market, better housing and lighting and many other factors which sometimes cannot be done under the old system.

Some Phases of Transportation

The second day of the Convocation was devoted to transportation, the morning session being taken up entirely with passenger traffic in the Chicago area. C. V. Weston, (M. W. S. E.) Con-

sulting Engineer, Chicago Surface Lines, read the first paper which was on the subject "Urban Transportation, Rapid Transit and Surface Lines." In this paper Mr. Weston outlined the volume of passenger traffic at present with a description of the equipment used and concluded with recommendations for a unified and co-ordinated traffic system, designed to serve the needs of this community and permit extension as required.

Maj. George A. Quinlan, (M. W. S. E.) Superintendent of Highways, Cook County, read a most interesting paper on "Vehicular Traffic in Chicago and Cook County." Maj. Quinlan was recently in charge of a detailed traffic survey conducted by the United States Bureau of Roads and the Department of Highways of Cook County, for the purpose of analyzing the vehicular traffic preparatory to making recommendations for an adequate highway system. One of the most important things Maj. Quinlan brought out was the fact that there are only thirteen highways leading into the City. The vast amount of traffic passing through each of these narrow gateways results in a condition of unbearable congestion. A study of the roads in Cook County revealed another startling situation. Maj. Quinlan showed two maps, one showing only the north and south highways and the other showing only those going east and west. It is a revelation to see these maps, to note how few continuous avenues of travel are open. The construction of a few comparatively short connecting links, would result in a great increase in carrying capacity. The studies made by Maj. Quinlan form the basis on which an adequate highway system for Cook County is to be laid out.

B. J. Fallon, (M. W. S. E.), General Manager, Chicago Rapid Transit Lines, read a paper on "Suburban Electric and Steam Railway Traffic." This paper set forth the general outline of the suburban passenger business in the Chicago area, it's probable development and growth.

The morning session was arranged by a sub-committee under the chairmanship of H. L. Kellogg.

A buffet luncheon was served in the Society rooms for the convenience of all those who wished to stay over for the afternoon session.

Terminals Are Important

In the afternoon the subject of Rail and Water Terminals was taken up for discussion. The program was arranged by the sub-committee under the chairmanship of Maj. Rufus W. Putnam, U. S. Engineer, Chicago. Maj. Putnam, who himself is an authority on terminals was scheduled to read a paper on "Fundamentals of Terminal Planning." He was unexpectedly called out of the City on that date, but his prepared paper was read by Secretary Edgar S. Nethercut. This was a general discussion of the fundamental principals that are desirable in the design of waterway terminals, for the expeditious transfer of freight, from rail to water and vice versa.

E. H. Lee, (Past President, W. S. E.), Vice-President and General Manager, Chicago and Western Indiana Railroad read a paper on "Railborne Commerce in the Chicago Region and its Requirements." The subject is self explanatory. A study of the freight traffic shows a total of about 30,000 freight car movements every day in Chicago. More than 4,000 industries have private track connections. It is easily seen that the freight traffic in the Chicago area is a business of no mean proportions. More than 1300 passenger trains enter and leave the city every day. The fact that no through train runs beyond Chicago means that this is the great transfer point for both freight and passengers. Studies for the improvement of this vast traffic are being made constantly. The most pressing need at the present time seems to be a revision of the terminals lying south of the business district of Chicago, opening up several new streets and straitening and widening the south branch of the Chicago River. Mr. Lee pointed out that in the many statements that have been made, concerning this project, there

are a number of conflicting assertions, some of which are not borne out by investigation of facts. He pointed out that straightening the Chicago River is a project that can be compared to the widening of North Michigan avenue. The railroads could no more be expected to straighten the River than property owners could be expected to widen Michigan avenue.

E. O. Griffenhagen, A. W. S. E., presented a complete analysis of the waterborne traffic of the Chicago area in his paper entitled "Waterborne Commerce in the Chicago Region and its Requirements." He described the volume of this business in the early days when the railroads were not so well developed and its subsequent decline. There are some commodities such as sand, gravel, coal, grain, etc., which still make up a heavy volume of waterborne traffic, but many of these have been transferred to the South Chicago area, where convenient rail connections are available, outside the congested area in the city of Chicago. Mr. Griffenhagen discussed the advantages of converting the bridges over the Chicago River to fixed bridges, instead of movable as at present and pointed out the need for planning of future development by the new Port Commission, which has been authorized. His review of the proposed harbor districts in Chicago, showed how they are supposed to handle the freight traffic. He emphasized particularly, that the time to do the planning for the future development, which means so much to the industrial prosperity of the City, is now.

Climax at Dinner Meeting

The Dinner Meeting at the Hamilton Club, Friday evening was enjoyed by about a hundred members. After the dinner was served, President Howson called the meeting to order, with a brief history of the Convocations which have preceded. This review showed that the Western Society of Engineers, has given serious thought to public matters, effecting Chicago and the vicinity in which engineering plays a large part. This was given as evidence of the fact, that engineers appreciate their civic responsibilities, conferred upon them by their specialized training. These Convocations have performed a distinct service for the City and have received considerable attention from the public.

Mr. Howson then called upon the chairmen of the subcommittees who have had the program of the Convocation in charge and asked each of them to present a summary of the program and their recommendation. These will be consolidated into a report which will be presented to our Board of Direction for approval and then issued to the public as the recommendation of the Western Society of Engineers, covering certain fundamentals.

President Howson then introduced our guest of the evening, Henry P. Chandler, President of the City Club of Chicago. Mr. Chandler paid high tribute to the engineers as an organized profession for their constructive achievements. He gave an interesting analysis of the growth or characteristic tendencies in the history of America. First was the period characterized by the prevalence of abstract political ideas, which was the situation at the time of the American revolution. With the introduction of steam engines and factory systems came an era of great business development, when the self-made man, so-called was the man in power. This was followed by an era of desire for knowledge characterized by the development of scientific and technical schools all over the country. This has led us into the present era of exact knowledge in business but in government we are still more or less ruled by the old ideals.

Mr. Chandler pointed out that the same evolution must take place in our government as has occurred in our industrial life. We can no longer be limited by abstract political theories. Organizations such as the Western Society of Engnneers can accomplish a great deal in showing the need for exact knowledge of facts in government.

Patents

Every engineer at some time or other has something to do with articles which are protected by patent and therefore should have an interest in the forms and limitations of general patent practice.

William O. Belt, President, Patent Law Association of Chicago, addressed the meeting of the Society, February 2, on these general terms and conditions. He described the beginning of the system of granting patents in the United States, which started more than 130 years ago, when the constitution was framed, including a short clause giving Congress the power to grant inventors the exclusive right to their discoveries. This word "discoveries" in the Constitution is considered as the foundation of our patent system.

The patent office has grown so that during the last year 75,000 applications for patents were filed and more than half of that number were granted. To carry on this work required a staff of about 600 specialists who are known as Examiners. The term of a patent is 17 years and during the last year, almost as many patents expired by limitation of their term, as there were new patents granted.

There are certain requirements or conditions which must be met before an application for patent can be granted. Working models are required only in special instances, although it was the principal requirement in the early days of the patent office. The invention must not have been known or used by others in this country, it must not have been patented or described in a printed publication, nor it must not have been in public use for more than two years if the inventor is to be given a patent. Also it must not have been abandoned.

The question "What is an Invention", requires careful interpretation to determine whether an article is a fit subject for a patent. There have been many legal opinions handed down setting forth in exact detail what may be defined as an invention. Generally speaking invention involves the conception of result desired and the demonstration of a way to obtain it. A new arrangement of an old combination or adding a new element to an old combination to produce a new result, may be an invention. A slight change in an old combination or process to accomplish a hitherto unattained result may constitute an invention.

There is a popular impression that a patent is a real monopoly of the manufacture or use of the article patented, but in reality only gives the owner the right to bring suit in the Federal Court for infringement. There is also another impression that anyone can make a patented article for his own use, so long as he does not sell it. Any person so doing is liable, and may be sued for infringement.

In general it is the object of the patent laws to protect the man with the idea, or the real inventor. Mr. Belt illustrated his remarks with a number of examples of famous patent cases.

"Ifco"

"IFCO" is a word representing a motto around which Superintendent William McAndrew of the Chicago schools built his address before the Western Society of Engineers, at the Noonday Luncheon, February 13. His announced subject was "Your School," and he addressed himself to the members present as representing citizens of Chicago, who are primarily interested in the conduct of the schools which receive for their operation almost a half of the money paid into the local government as taxes. He paid a compliment to the engineers when he suggested that it might be the salvation of the Chicago schools to put engineers in charge of their management. In his college days he had associated with a student who was studying engineering and who did not have time to take much part in social affairs, because he said he had to work, he was an engineer. Mr. McAndrew took issue with the old doctrine that the purpose of education was to prepare the student to enjoy leisure. Chicago children spend only five hours per day for 196 days out of each year in school.

This same friend of Mr. McAndrew's

college days, had a nickname, "Ifco", which is made from the initials of a motto, that he frequently quoted: namely, "Investigate, Formulate, Calculate, Operate" which was said to be the rule established by the general staff of the German Army, as a method for solving every problem. Supt. McAndrew inquired why it could not be applied to the management of a large school system and then proceeded to show how it could be applied to Chicago with profit. Formerly there was no investigation worthy of the name and educational methods were based on many unproved assertions, for example, that the study of Latin was essential to anyone who thought of entering the professions. Investigation showed that proficiency in Latin was not an assurance of success in later life. This applied also to other branches of study, such as Algebra, which was recommended because it was supposed to teach one to think.

Another belief which has been pretty fairly exploded by investigation is that he who whispers when he reads, or reads slowly, acquires a more correct perception of the thought presented in the matter read. Careful investigations have shown that the rapid reader, who does not whisper, gets a better understanding and remembers longer, what he has read and there is logical explanation for this. Any physical act performed while reading, detracts from the total nerve force contained in the human system and reduces the possibility of thought-perception by just that amount. These experiments led school authorities to introduce the teaching of silent reading in the school, eliminating oral reading entirely, just as early in the child's course as it could be done with assurance that the teacher could determine that the child perceived what was being read.

Business men prove every calculation in the conduct of their business, or they fail. Mr. McAndrew believes that pupils in school should be taught to prove everything in their lessons, that is capable of proof. He has introduced this doctrine into the Chicago schools and every child is now required to submit the proof of every problem before it is accepted. He asks why the schools should be allowed to teach children to guess at results.

Turning to the motto again, he suggested that we investigate the schools in Chicago and find out what they return to the people who support them. The fundamental law of the state requires that the schools shall give a thorough and efficient common school education. Investigating what this means it is understood that a common school education embraces at least the fundamentals, reading, in which there should be taught a perfect perception of the matter read, writing, in which the desired result is legibility and arithmetic, where accuracy is desired above all things. The law also requires that there shall be one hour a week devoted to the teaching of Civil Government to all pupils above the sixth grade.

The law does formulate what shall be done. The rest of the motto must be supplied by the management which must calculate, how the things described by the law shall be done, and operate, which can be simply expressed by the injunction, "Do It."

Mr. McAndrew suggested that another letter might be added to the motto, signifying evaluate, which would mean to establish a standard by which the result could be measured. Such a standard has already been put into operation by which it is hoped that the schools of Chicago may be graded to determine whether they are above standard or below. This standard of schools is based on a number of things such as, the following: buildings and grounds, their neatness and cleanliness; complete adherence to the policy of proving everything by the students; penmanship as measured by all written work; records of lesson plans; conferences of principals and teachers; minutes of meetings held and records of work done; meetings of teachers to compare notes; promptness in rendering reports; fire drills. To these may be added such things as general assemblies, study of pictures and art, and neighborhood meetings.

Propose Uniform Building Contract

A standard form of contract that will fit all sorts of construction project seems like a dream but it is becoming as nearly a reality as it is possible for any thing of that kind to be. This proposed form of contract was discussed at our meeting, February 9.

The Western Society of Engineers had a part in framing this proposed standard contract.

We have had a committee under the chairmanship of J. D'Esposito working with similar committees from seven national organizations interested in engineering construction and construction of buildings in a joint conference to draw up a form of contract that might be submitted to the building industry for adoption as a standard. This committee has been meeting regularly and has had the whole-hearted support of the Department of Commerce of the United States under Secretary Herbert Hoover. Onward Bates, Past President, W. S. E. was chosen Chairman of the general conference but his health permitted him to attend only a part of the sessions. John W. Cowper, M. W. S. E. of Buffalo, N. Y., was chosen vice-chairman of the general conference and upon him fell most of the active work of conducting the meetings.

In preparing the program for this meeting it was the thought of the committee that speakers would be asked to discuss the proposed form of contract from the viewpoint of engineers engaged in all of the lines of construction represented. Richard E. Schmidt, M. W. S. E. of Schmidt, Garden & Martin discussed the contract from the standpoint of an architect. He outlined the forms previously used by the American Institute of Architects and gave a general description of the new form and the principal features of it.

J. D'Esposito, M. W. S. E., Chief Engineer, Chicago Union Station Co., who has been the chairman of the committee of the Western Society of Engineers co-operating with the general conference went a little further into the method of operation of the contract and its provisions. Mr. D'Esposito's large experience in handling engineering construction problems under contract gave him many examples to illustrate the points discussed.

Through all of the remarks made during the evening it was apparent that the question of an arbitration clause was the one on which there was the most difference of opinion. The proposed form of contract contains an arbitration clause providing for a board of arbitration consisting of one member selected by the owner, one by the contractor and the third to be selected by those two. There is a strong sentiment that it would be equally desirable to make the engineer in charge the sole arbitrator.

John W. Cowper who was vice-chairman of the joint committee came from Buffalo to be present at this meeting and tell some of the work that the conference had done in drawing up the proposed form. It is obvious that an undertaking of this magnitude presented a number of complications which had to be adjusted. Mr. Cowper pointed out the importance of having a contract form that is acceptable in any state where work is to be done, and that covers the conditions which are likely to arise. He said that the contract would be introduced in every department of the federal government within a few months. The contract contains the arbitration clause which is something entirely new for the government departments to accept.

E. P. Rich, M. W. S. E. Consulting Engineer, Neiler, Rich & Co., discussed the contract from the standpoint of the mechanical engineers and the mechanical trades interested in building. His experience has been that there is very little necessity for general conditions in a contract if the parties understand each other and if the specifications and drawings are clear and correct there should be no occasion for any controversies. However general conditions of the contract are necessary to guard against the possibility that there might be a misunderstanding. He pointed out a num-

ber of minor variations in the contracts which might be peculiar to a certain trade.

Electrical contractors were represented by Secretary Collins of the Chicago Electrical Contractors Association. He complimented the contract very highly saying that he considered it the fairest that he has ever seen in its treatment of the contractor. As in the mechanical trades there are certain minor differences that probably should be covered under a separate clause.

F. E. Morrow, M. W. S. E. spoke from the standpoint of the railroads who have done nearly all of their work under contract for many years. They represent the group which believes that the arbitration of a contract should be placed in the hands of the engineer in charge, but find little need for such arbitration when both parties understand what is covered by the contract.

Gardner C. Coughlen, M. W. S. E. was asked to discuss the contract from the standpoint of building constructors. He was unable to be present, but his discussion was read by Frank A. Randall, M. W. S. E. He pointed out a number of practical considerations that should be borne in mind in preparing the final form of contract for adoption. Among them he mentioned more accurate directions, for delivery of material, preparation of specifications and shop drawings by contractors, and the responsibility for changes in drawings, furnishing watchman service, temporary illumination, telephone service, hoisting apparatus, etc., all of which have to be understood by both parties, if any contract is going to be successful.

W. J. Lynch, M. W. S. E. Vice-President, Thompson-Starrett Co., spoke on behalf of the contractors. He raised the point of general clauses in specifications, being in conflict with those in the contract. There should be an understanding of which clause is to govern in all such cases. Another very important point that he mentioned was the contractor's guarantee of the work and what it is understood to cover. The matter of extension of time is another, which should be carefully provided for in drawing up a contract.

C. L. Post, M. W. S. E., spoke in favor of the arbitration clause not as the most satisfactory method of solving a controversy, but as an evidence of good faith on the part of both parties to the contract. Until a better method of reaching agreement is devised, he thought the arbitration method should be used.

The meeting closed with a testimonial of respect to Onward Bates, Past President, W. S. E., who lent his advise and counsel freely to the work of the joint conference.

W. S. E. Meeting Broadcast

The first meeting of the Western Society of Engineers to be broadcast over the radio, occurred Monday, February 16 when Lieutenant Leigh Wade, one of the American aviators, who recently flew around the world, spoke before the joint meeting of the Society and the Chicago Section, American Society of Mechanical Engineers at Kimball Hall.

For many months the committee in charge has been working on the plans for a meeting to be held in February on Aviation, but it was not until ten days before the meeting that it was definitely known, whether the speaker desired could be secured from the Air Service. At that late date it was impossible to secure any other hall, than Kimball Hall, which seats only about 500 people. This made it necessary to issue tickets to those desiring admission. Had there been any other room available for that date it would have been secured, as there were easily twice as many requests for tickets as we were able to supply. Tickets were given only to those members of either society, who presented their membership card, showing that their dues were paid up in full.

Lieutenant Wade's address was broadcast by station WTAS and there is no way of telling how many thousands of people heard it.

So much has been published about this trip that is well known and requires no description here. Lieutenant Wade mentioned many interesting personal experiences of the aviators and impressions that they gained in their visit to the vari-

ous foreign countries. The outstanding feature of the whole trip was the courtesy shown to the men wherever they landed. Each city endeavored to outdo the rest in the way of entertainment, which the men were unable to accept because of the shortness of time permitted at each stop.

This was an event of world wide interest, which was a demonstration of organization and efficiency. It was not a haphazard adventure but just the reverse as the most careful plans were made in advance, to be sure that the plans would not be detained because of lack of supplies or repair parts wherever needed.

The Air Service had motiòn picture photographers posted at every landing point on the entire trip to take pictures of the start and finish of each flight. These have been consolidated into a four reel film, which was shown at this meeting for the first time, outside the Air Service.

Paving Practice in Chicago

In common with many other things the pavements on our city streets have had to be rebuilt due to the introduction of automobiles. The slow moving traffic of a few years ago, using steel-tire wheels has been replaced by high-speed traffic with heavy loads moving on resilient-tire wheels. This has resulted in the elimination of water bound macadam pavement and the need of a stronger foundation of the so-called rigid type.

Temperature ranges in Chicago amount to about 140° F. which requires ample provision for expansion. The topography of the City of Chicago is exceedingly flat which introduces complications in the matter of drainage, requiring the use of a large number of catchbasins and expensive sewer connections, all of which adds materially to the cost of pavements. A variety of soils is encountered in the various parts of the city, which increases the difficulty of obtaining a suitable subgrade. These are some of the things brought out by John B. Hittell, (M. W. S. E.) Chief Street Engineer, Board of Local Improvements, City of Chicago in his paper before the Society on February 24. After enumerating the special questions to be solved in the design of our city pavements, Mr. Hittell proceeded to show how the Board of Local Improvements solves them. New specifications have been drawn up for asphalt pavements as well as those constructed entirely of Portland Cement concrete. Since the total expansion may approximate one inch per hundred feet, special provisions have been made to insure that it will be taken care of.

A. J. Schafmayer, (M. W. S. E.) Division Engineer, Board of Local Improvements, City of Chicago, followed with a well prepared paper on methods of resurfacing and widening existing streets. In this kind of work there is a larger variety of conditions to be overcome, than in building entirely new pavement. It is necessary to change the cross section in most cases to provide for greater strength and to eliminate the high crown at the center of the road, which is now considered undesirable. He described the field and office studies made on each of these projects and the methods employed in construction.

Widening of existing streets introduces still other things to be considered. This is a combination of new work and rejuvenation of old work. There is an increasing number of these projects coming up in Chicago all the time and here the engineers have an opportunity to exercise their best talent. Mr. Schafmayer described a number of the street widening projects, that are under way in Chicago now, telling how the new work was designed so as to join properly with the old. In one instance it was necessary to leave the gutters where they were and have the new portion at the sides slope upward from them.

Messrs. Hittell and Schafmayer exhibited a model of a street with concave cross sections, that is with the gutters in the center, instead of at the sidewalks. This type of construction would save about 15% in cost of the pavement principally because of the simplication of sewer and catchbasin construction. It has advantages also from the traffic standpoint

A Trip Around the World

One of the entertainment features on our program for March is the story of a trip around the world recently completed by one of our members, P. Albert Poppenhusen. This meeting occurred March 5. The following abstract was prepared by Mr. Poppenhusen and is a good outline of his address as he gave it. The account of his many amusing experiences was received by an audience that filled our room to capacity.

I was in need of a vacation and after having interviewed all of the various companies decided rather hurriedly to leave New York on February 21 on the Dollar Steam Line and have had no occasion to regret my rather hasty decision.

We left New York for Cuba after a very heavy snow storm, but were fortunate in missing several storms before reaching Havana. After a short stay in Havana, where most of us proceeded to fortify ourselves against a possible dry season, we had a very interesting trip through the Panama Canal—the Gatun Lake and the Slides in the Culebra Cut being of especial interest. The day was muggy and misty, however, the temperature was bearable and I understand that especially on the Pacific side it is never uncomfortably hot. The trip up to Los Angeles was interesting—mainly on account of the varied sea life which we encountered, especially millions of flying fish, sea turtles, etc. Another interesting spectacle was a school of porpoise approximately a mile or more in length.

After a brief stop in Los Angeles and San Francisco, we proceeded to Hawaii—spending a wonderful day in Honolulu and thence to Kobe, Japan. This trip was rather rough, especially two days out of Kobe where we encountered a cyclone which did quite a little damage.

Japan is a very enchanting country and to me especially interesting, as I have had the pleasure of doing business with one of the largest Japanese houses for the last twenty years, the result of which was that we were met at the boat and from that time on entertained daily by friends. Nothing was too much trouble for them in the way of entertainment or preparations made for us at various hotels.

We were fortunate in having native friends as it gave us an opportunity to see native life which is accorded to very few visitors. In my slides I shall show some of the native Japanese life, especially a very good slide of school children who followed us from place to place. Japan is intensely cultivated and in spots such as in Nikko, Kyoto and Narra, wonderfully beautiful mainly due to trees, centuries old—which on account of the intense cultivation—are not ordinarily seen in Japan.

We had made no set plans so that we extended our visit in Japan for one more week and then changed our original plans to take in Korea as well as China. In Korea we had the good fortune to meet Governor General Baron Admiral De Saito who insisted on entertaining us durnig our stay in Seoul which is now called Kejo. Due to this happy circumstance we had the good fortune to be guided by the head of the Intelligence Department thereby seeing the Imperial Korean Palace Sacred Gardens and other places which are usually denied the casual visitor. From Kejo we went to Mukden, at which point we left the comparatively comfortable Japanese railway and embarked on the worst trip that I have ever taken—twenty-four hours to Peking. In Peking we had friends and were fortunate enough to spend three days in a Buddah Temple in the Western hills where the Priests still worship daily.

We also had typical Chinese dinners consisting of shark fins, thousand year old duck eggs, birds' nest soup and other delicacies—including duck brain and duck feet. I found, however, that Chinese meals do not differ much from Japanese food. They all eat anything that flies, walks, crawls, burrows or swims.

Our trip to Hankow in an armored train guarded by fifty or more Chinese soldiers was fairly comfortable and very interesting. At Hankow we took a

Chinese boat down the Yangste to Shanghai which is a very interesting and progressive town, at least as far as the Foreign Concessions are concerned. Here we saw the first English influence, especially as it pertained to the policing of the European concession.

Hong Kong which we reached a few days later is entirely English and is a beautiful place. Manila was interesting but not as much as I had expected. We were there during the off season, vegetation being pretty well dried up. Our next stop was in Singapore which according to books I had read I had expected it to be the worst town in the world—which is its reputation. While we saw a great many wonderful and impossible things, yet as in all of these towns the European section is well kept up and the hotels very comfortable and attractive. Penang and Rangoon ended our stay in the Straits Settlements and Burma. Ragoon was most interesting and was the first town where we saw elephants doing actual work. The trip to Calcutta was a very disagreeable one as we struck the little Monsoon. The boat was small and therefore most of the passengers suffered from Mal de Mer. Calcutta was just a trifle hot—120° in the shade. A tiger hunt had been arranged for us but we decided to cancel same and take the first train we could to Darjeeling which is the summer resort for Calcutta, being at an altitude of about 4,000 feet. We passed through wonderful jungles in which the tiger still roams and through the great tea estates of Sir Thomas Lipton.

From Tiger Hill we had a good view of Mt. Everest and Kitchen Junga only a few hundred feet lower than Mt. Everest,—which towers up to 29,700 feet. Upon our return to Calcutta,—it being still hot—we decided to go up to that wonderful country about which we knew nothing—Kashmir—in the midst of the Western Himalaya Mountains. There are no railways in Kashmir so we travelled 250 miles by automobile to the capital—Spinager, which lies in the valley of Kashmir at an altitude of 6,000 feet surrounded by snow capped mountains which are 22,000 to 26,000 feet in height. Sprinager is cut up by lakes, rivers and canals so that transportation and shopping is entirely by water with the exception of the English section.

As usual the English had a polo field, golf course and the inevitable tennis court. While up there we lived on a house boat which we found very comfortable. On our return we stopped at Delhi, Agra and Jaipur. This was the most interesting part of our trip. Wild peacocks were all over the town. We slept on the roof of the hotel at night, rode elephants and fed the wild monkeys, which daily go to town in big troops—presumably for shopping purposes and return to their mountain haunts at night.

Next Bombay which is of Phoenician origin. Here we saw the Towers of Silence, Hindu Ghat and Elephanti Islands with their ancient caves and then across India to Madras to Colombo, Ceylon where we took a short jaunt into the interior and returned in time to catch the boat for Suez. We left the boat at Suez and took an automobile ride across the desert to Cairo where we rode camels, saw the pyramids and other interesting sights. Then to Alexandria and by boat to Naples.

I will not weary you with our trip through Italy, Switzerland, Germany, Holland and England. From London we flew by the Imperial Railways Air Line to Paris where we had a delightful stay and then sailed for New York from Marseilles.

It is a very hard matter to make a short story of such a long trip, I have therefore touched only a few of the high spots but hope that my 80 slides and my talk may be of sufficient interest to be enjoyed by the members and their ladies.

An interesting request has been received from one of our members for permission to translate into Arabic one of the papers published in the Journal last winter so that it can be published in a magazine in Egypt. The permission has been given and it is needless to say that we await receipt of the publication containing this article with a great deal of interest.

Library Has Books For Sale

Due to the lack of space for duplicate material in the Library, the Society is placing at the disopal of its members a collection of about 250 volumes on various subjects. Come in and see the books. You may be able to pick up material of considerable value for very little money. First come, first served. Speak to the librarian immediately about those in which you are interested.

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See Flow Meters Made

An instructive excursion was held at the Republic Flow Meters Co. plant at 2240 Diversey Parkway, Saturday, February 14. J. D. Cunningham (M. W. S. E.), President of the Republic Flow Meters Co. expressed his pleasure of having the opportunity of playing host to members of the Western Society of Engineers in his new factory. He provided enough guides to take the members through in small groups, so that every one had opportunity to ask questions and see everything that was being shown.

Only enough of the employees were at work to show the more interesting things as it was Saturday afternoon. The more ordinary shop machines such as lathes, punch presses, milling machines, drill presses, etc., were not running.

The parts of the factory in which our members were most interested were the inspection department, tool room, laboratory, and electrical assembly.

This Company manufactures a line of

instruments for measuring the flow of steam, air, water, gas, draft and coal. The use of these instruments is comparatively recent and our members were glad of an opportunity to familiarize themselves with their construction and operation.

This factory was designed and built to suit the particular requirements of the company's business. The building is two-story, reinforced concrete construction, with ample room for extension as may be required by increasing business. The machine shop has all operations which might cause dirt or vibration, carried on in a separate part of the building from the department where very delicate work is being done. Especial interest was shown in the testing department, where all instruments are tested under actual pressure 1000 lbs. per square inch. Here also is an elaborate equipment used by the research laboratory, in studying the effect of the flow of steam and gases through orifices. It was here that J. M. Spitzglass (M. W. S. E.), developed his table of orifice constants. The research laboratory is completely equipped with apparatus for investigating new ideas and theories in the construction of meters.

Appeals in Advertising

One of the recent meetings of the Young Men's Forum was addressed by Morris Wisner Lee (M. W. S. E.), who is a specialist in the advertising field, on the subject of "Appeals in Advertising." His own abstract of his remarks at that time is given here.

"The proper way to present an advertisement, it seems to me, is somewhat similar to the proper way to serve a piece of pie. The consumer likes to have the easiest point of apprach turned toward him. If a waitress puts a piece of pie down in front of him with the point the wrong way, he will turn the plate, but there are few people who will turn an ad around to find its greatest appeal.

"Advertising must have an appeal because it concerns human beings—all of them imbued with self-interest. To be effective the advertising must show people that the action requested by it leads in the direction of their interest.

"I am a firm believer in the universal appeal of beauty. Of course, a piece of mechanical equipment should not be done in a 'pretty-pretty style' such as might be used for lingerie or a Coles Phillips stocking ad. The design, arrangement, type face, and so on, should be in harmony with the article advertised.

"One phase of beauty is pleasing form and proportion, a nice balance between the black and white masses of the printed page. This factor is sometimes disregarded by advertisers in their effort to crowd a lot of selling arguments under the buyer's eye, with a resulting loss of attention.

"Another element of beauty is repose. The advertisement upon which the eye can rest without effort is the one that the buyer is apt to read rather than the page which demands his attention in several spots at once.

"Most writers and speakers on advertising will tell you that to gain attention is the first essential of any advertising,—and this is true. The injunction is interpreted sometimes, however, as a necessity for screaming headlines. If you scream in your headlines to arrest attention, elaborate your story promptly in a way that can be easily grasped, otherwise the buyer will be annoyed by your noise, and turn against your product.

"The appeal for action,—and this is the appeal all advertising should carry, should play upon the impelling motives of the buyer. Among these motives are self-preservation, property, power and reputation. You have noticed that advertisers of medical products play strongly upon the motive of self-preservation. In industrial pursuits, however, the appeal is more to the motives of power and property—the motive of self-interest or gain.

"It is apparent that if we are going to embody these desirable elements of appeal in our advertising, we have to know something of what our prospects are thinking about, because we have to get into their experience with our sales talk. To gain belief for your argument and so to get action from your prospects, it is necessary to proceed from the known to the unknown. You gain credence for the unaccepted by presenting its relation to the accepted thing.

"And above all, clearness and definiteness must be put into advertising for it to have a constructive appeal. Thoughts have to be made clear and definite for the other fellow to comprehend them.

"Ernest Elmo Calkins, who is probably the dean of advertising men, says there is one element of value in adevertising upon which practically everybody is agreed, and that is the value of repetition.

'Keeping everlastingly at it brings success,' is a slogan that presistent advertisers have proved true.

"Engineering and industrial advertising, the branch in which I assume you are most interested, used to consist mostly of small cards or bald statements of fact. When it was realized that this was not the best form of advertising, the next stage was to fill the space full of technical copy, which few of the buyers could understand and still fewer were interested in.

"The most recent stage, and, I believe, the most intelligent one, which industrial and engineering advertising has reached is the stage where the products are presented in a human way with a natural appeal to human motives. It is important to know this if you are advertising, because competition among advertisers of engineering products is constantly growing keener, and your ad must embody the right element if it is to bring you the desired business."

A New Kind of Gas Holder

Something new in the way of gas holders was described at our meeting, January 19, by Alten S. Miller, Vice-President, Bartlett Hayward Co., Baltimore, Md. This new holder is a fixed structure in which a piston moves up and down instead of being a sort of collapsible tank.

This new structure is in the shape of a polygon, generally of a height greater than its diameter. The vital part in the operation of the holder is the joint between the piston and the walls of the holder. This is accomplished by means of specially devised tar seal.

The holder is quite large in size and built of light material, wherever, possible, as structural strength is not required to hold the gas. The problem of erection and framing to insure rigidity requires some very careful attention to detail.

Since this type of holder is much lighter than the one ordinarily used, the expense for foundations is very much less. There has been a number of these piston type waterless gas holders built in Europe, but only a few of them in this country. Mr. Miller used a large number of photographs and drawings to illustrate his address, which showed very fully the details of design and construction.

Machine Tool Meetings

Members of the society may be interested in the machine tool meetings to be held by the Chicago Section of the American Society of Mechanical Engineers. There will be an afternoon and evening meeting devoted to presentation of present day aspects and tendencies in design and operation of metal-cutting machinery. The discussion is intended to be of particular benefit to users of machine tools.

Meetings will be held March 11, 1925. The afternoon meeting will open at 2 P. M., in the rooms of the Western Society of Engineers, Monadnock Bldg. At this session the following topics will be presented:

"Trend of Machine Tool Design," Author to be announced.

"What We Want in Machine Tools," by Robert R. Keith, Supt., Chicago Tractor Works, International Harvester Co.

"Die Cast versus Machined Parts," by S. A. Hellings, Vice Pres. Stewart Manufacturing Corp., Chicago.

At 6:30 P. M., there will be a reservation dinner at the City Club, 315 Plymouth Place, where the evening session also will be held.

The evening session will be devoted to a symposium on the Finishing of Planed Surfaces, which will be divided into two sections: one dealing with large surfaces and discussing heavy milling machines and planers; the other section on small surfaces dealing with light milling machines and disc grinders.

In the first section heavy milling machines will be discussed by a representative of Ingersoll Milling Machine Co., of Rockford, Ill., and planers by Forrest E. Cardullo, Chief Engineer of G. A. Gray Co. of Cincinnati. In the section dealing with small surfaces, light milling machines will be discussed by W. W. Tangeman of Cincinnati Milling Machine Co., and disc grinders by F. E. Gardner, Vice President of Gardner Machine Co. of Beloit, Wis.

Public Affairs Committee Considers Child Labor Amendment

The proposed twentieth amendment to the constitution of the United States giving Congress the power to regulate and prohibit the labor of persons under eighteen years of age has been before our Public Affairs Committee for the past six weeks and has aroused considerable discussion. The matter was first brought before the committee December 15. B. F. Affleck, President, Universal Portland Cement Company, appeared before the committee and gave a history of the movement to have this amendment placed on the statutes. He stated the arguments for and against the adoption of such a law. The matter was referred to the Sub-Committee on Public Health for report at the January 12 meeting.

After consideration by the sub-committee a report not in favor of the amendment was presented. It was felt that the members of the committee had not heard sufficient evidence to permit them to come to a conclusion so Miss Jane Addams, head resident of Hull House, who has been very active in support of the measure was asked to present her views before the committee at that time. Miss Addams presented the viewpoints of the numerous women's organizations which are working for the passage of the emendment. Although she had intended to speak only a few minutes, she was kept busy answering questions for over half an hour. The discussion that followed her remarks took up the entire time of the committee at that meeting which resulted in a decision to refer the question again to the sub-committee for further report.

The second report of the sub-committee was brought up at the meeting on January 26, at which time it was decided that a referendum of the entire Public Affairs Committee should be taken by letter ballot before the resolution expressing the opinion of the Society should be transmitted to the Board of Directors for approval.

Describes Public Schools

A. P. Allen, Chairman of the Sub-Committee on Public Education, gave a interesting statement of the condition of the public schools in Chicago at the meeting on January 26. Perhaps few persons realize that the attendance at the public schools of Chicago has increased 43.5 percent in the last ten years, 25 percent in the last five years and is now increasing at the rate of about 5 percent per year. During this ten year period there has been only 3 percent increase in the school buildings. Statistics show that only 10 percent of the pupils who start in the grade schools finish high school.

It cost the board of education $81.00 per year for each pupil up to the seventh grade. The cost is almost double this amount per pupil for the grades higher than the seventh. A study of the statistics indicates that the majority of those dropping out of school do so at the seventh or ninth grade. The junior high school scheme which is now being introduced has two strong arguments in its favor. It induces those who would otherwise drop out at the seventh grade to continue to the ninth year and thus receive an abbreviated high school education. It also provides a way to accomodate the ninth year pupils in buildings which are much less expensive to maintain and operate than the senior high schools where they would otherwise have to be accomodated.

The building program of the board of education is based on the first thorough study of the school needs that has ever been made in Chicago. Mr. Allen showed a large map with the location of the elementary and junior high schools as proposed, indicated thereon. This shows that the junior high schools are needed in the congested areas which are now well built up and well supplied with elementary schools while the outlying areas are sadly in need of grade schools.

The present administration of the board of education has conducted tests which show improvement in the results obtained under more adequate discipline. The much discussed platoon system shows great economy and efficiency in the use of school buildings.

APPLICATIONS FOR MEMBERSHIP

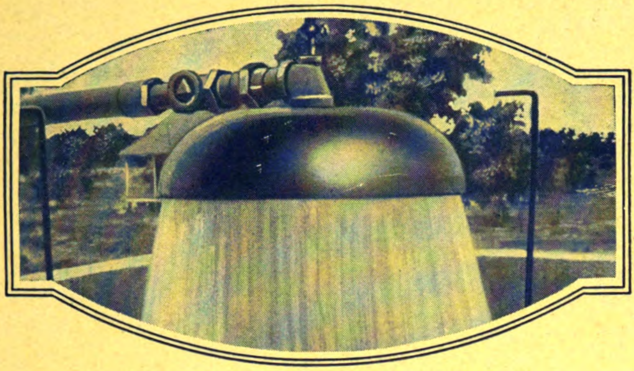
Members of the Society can be of great service if they will make a practice of examining the list of applicants published herewith and promptly notifying the Membership Committee or the Secretary regarding the qualifications of any of those whose names appear on the list. The Society desires to extend its membership and receive those engineers who have the proper qualifications and wish to participate in its activities. The following applications have been received since last report:

No.	Name	Address
560—1924	Richard T. McKay	119 E. 59th St., Chicago, Ill.
561	Herbert B. Fay	Box, 182, Angola, Ind.
1—1925	Edward W. Prentiss (Transfer)	4030 N. Paulina St., Chicago, Ill.
2	Theodore W. Miller	1524 Monadnock Block, Chicago, Ill.
3	Antonio J. Papa	2040 S. College St., Angola, Ind.
4	Frank R. Johnson	2706 S. Michigan Ave., Chicago, Ill.
5	Walter E. Rasmus	1733 Gregory St., Chicago, Ill.
6	Jorge Maroto	3935 W. Monroe St., Chicago, Ill.
7	John B. Millis	Byron, Ill.
8	Walter F. Glauser	162 W. 74th St., Chicago, Ill.
9	Felix Z. Tiongco	6245 Kenwood Ave., Chicago, Ill.
10	John W. Leppan	5778 Portage Ave., Cleveland, Ohio.
11	Howard Ford	207 E. South St., Angola, Ind.
12	A. W. Seels	10535 Prospect Ave., Chicago, Ill.

NEW MEMBERS

The following were elected to membership in the grade shown by the Board of Direction at its meeting January 19, 1925.

No.	Name	Address	Grade
527—1924	Leo L. Michuda	11127 Lowe Ave., Chicago, Ill.	Student
528	Grover O. Melby	1745 Merrimac Ave., Chicago, Ill.	Student
529	Nellis J. Wagner	Box 1, Argo, Ill.	Student
530	Clifford E. Ives	1304 Monadnock Block, Chicago, Ill.	Associate
531	Russell C. Kinsman	Box 271, Villa Park, Ill.	Associate
532	Harold W. Munday (Transfer)	1218 Elmdale Ave., Chicago, Ill.	Junior
533	Max L. Loewenberg (Transfer)	111 W. Monroe St., Chicago, Ill.	Member
534	Leo Krumdieck (Transfer)	3654 S. Robey St., Chicago, Ill.	Affiliate
535	Howard E. Norton	614 Central Ave., Wilmette, Ill.	Student
536	Samuel R. Willey	2053 E. 68th St., Chicago, Ill.	Student
537	Ralph L. Ward	825 Ayars Pl., Evanston, Ill.	Student
538	Richard H. V. Shaw	Bldg. Dept., Illinois Central R. R.	Junior
539	Samuel Deutsch	4454 N. Albany Ave., Chicago, Ill.	Junior
541	Harry M. Paetow	1537 W. 59th St., Chicag, Ill.	Junior
543	J. Lyell Clarke	1524 E. 61st St., Chicago, Ill.	Member
544	L. V. Castiglione	925 S. Wenonah Ave., Oak Park, Ill.	Junior
545	E. M. Goodman (Transfer)	1719 Ridge Ave., Evanston, Ill.	Junior
546	Charles Singman	1425 N. Rockwell St., Chicago, Ill.	Junior
547	Edgar F. Osius	301 N. Mason Ave., Chicago, Ill.	Junior
548	Adrian A. Purvis	301 N. Humphery Ave., Oak Park, Ill.	Junior
549	Fletcher W. Pearce	6444 Ellis Ave., Chicago, Ill.	Junior
550	Axel O. Jansson	2035 Leland Ave., Chicago, Ill.	Associate
551	William L. Kelly	704 W. Marquette Rd., Chicago, Ill.	Associate
552	Earl R. Geiger	3643 W. 65th St., Chicago, Ill.	Student
553	Walter J. Giryotas	5964 W. Adams St., Chicago, Ill.	Associate
555	John L. Oberly	848 Eastwood Ave., Chicago, Ill.	Junior
556	Joseph H. Carr	7639 Eastlake Terrace, Chicago, Ill.	Associate
559	Orin H. Taylor	Room 532-160 N. La Salle St., Chicago	Member



Who Uses "Air Lift"?

Evergreen, Ala.
Bisbee, Ariz.
Lake Village, Ark.
Hayward, Calif.
Wellington, Colo.
Daytona, Fla.
Ocilla, Ga.
Emmett, Idaho
Galesburg, Ill.
Galva, Ill.
Glen Ellyn, Ill.
Kewanee, Ill.
Melrose Park, Ill.
Odell, Ill.
Park Ridge, Ill.
Peru, Ill.
River Forest, Ill.
Bluffton, Ind.
Dubuque, Ia.
Marcus, Ia.
Stewart, Ia.
Washington, Ia.
Greenleaf, Kan.
Lincoln, Kan.
Amite, La.
Lake Place, La.
Natchitoches, La.
Plaquemnie, La.
Winesboro, La.
Reading, Mass.
Cambridge, Md.
Farmington, Mich.
Albert Lea, Minn.
Buhl, Minn.
Owatonna, Minn.

Advantages of air lift pumping from deep wells have been related in detail in this space many times.

"Where is air lift used and by whom?" is a fair question, and one to which you should have a satisfactory answer before you buy your well pumping equipment. Here it is!

We can give you names and details of over 200 cities, towns and villages in 38 different states, which have installed Sullivan Air Lift plants within the past ten years. Perhaps one or more of the partial list printed here is near you. If so, ask their Water Department as to results.

Meanwhile, send for our new air lift catalog No. 2071-H

Rochester, Minn.
So. St. Paul, Minn.
Willmar, Minn.
New Albany, Miss.
Raymond, Miss.
De Soto, Mo.
Syracuse, Mo.
Bancroft, Neb.
Beach Haven, N. J.
Summit, N. J.
Williamstown, N. C.
Ansonia, Ohio
Wilmington, Ohio
Drumright, Okla.
Duncan, Okla.
Miami, Okla.
Picher, Okla.
Duquesne, Pa.
Fountain, S. C.
Aberdeen, S. D.
Dickinson, S. D.
Redfield, S. D.
Greenfield, Tenn.
Arlington, Tex.
Brady, Tex.
Caldwell, Tex.
Dallas, Tex.
Galveston, Tex.
Honey Grove, Tex.
Whitewright, Tex.
Ogden, Utah
Mt. Hope, W. Va.
Mullens, W. Va.
Oak Hill, W. Va.
Kaukauna, Wis.
Stoughton, Wis.

SULLIVAN MACHINERY COMPANY

122 South Michigan Avenue **CHICAGO, ILL., U. S. A.**

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FEATURES ON THE APRIL PROGRAM

April and May promise to be the two best months in the Society's year as far as the technical program is concerned. Perhaps this is unfortunate in one way as it is pretty hard to sit through a Technical meeting when the weather is pleasant and everyone wants to be out of doors. There are several features on this program that are worth special mention.

Carrier Current Telephony on High Voltage Lines

The first meeting of the month will be April 6, when N. H. Slaughter, one of the engineers from the Bell Laboratories, Inc., formerly the Research Laboratories, American Telegraph and Telephone Co. of New York, will present a paper on "Carrier Current Telephony on High Voltage Lines." The system that has been worked out by the Bell Laboratories, solves one of the serious problems that has confronted power companies since the beginning of high voltage transmission. Efforts have been made constantly to develop telephone systems on the same towers or poles that carry the high voltage lines. The troubles that have been encountered have been numerous and the results have not been without danger to operators.

It remained for the Bell Laboratories to develop a scheme whereby the power transmission wires themselves were used for telephone purposes. This system does away with the danger which might result from crossed wires which because they are not connected directly to the high voltage system are not properly protected. The invention of the Carrier Current System is not the invention of a single man but rather the result of continued research on the part of a trained staff of specialists determined to solve a particular problem and properly equipped with all the scientific apparatus that is required.

This paper will be well illustrated and should appeal to the engineers of the power companies as well as those who are interested strictly in telephony.

Material Handling

A scientific study of the methods of handling material in process of manufacture will be presented at our meeting April 13 by F. J. Feeley, Development Engineer, Hawthorne Works, Western Electric Co.

This paper describes the systems in use at the Hawthorne Works, which are figured on an actual dollars and cents basis. Every operation has been thoroughly studied by trained engineers, who have analyzed all of the different kinds of material handling equipped with reference to the particular operation being studied. The method finally adopted is not the result of any snap judgment or personal choice.

Particular attention has been paid to storage battery locomotives and trailer systems in handling bulk material. At other points, overhead monorail systems are used, while at still others belt conveyors have been found to be most satisfactory.

The subject of Material Handling is one of which a great deal has been written and a great deal remains yet to be said. The careful studies of an organization like the Western Electric Co. should be of interest to manufacturers in most any line of industry.

Pageant and Spectacular Illumination

The meeting on April 20 will be of a more spectacular nature than is usually found on our programs and although it is interesting, it is probable that not many of our members are actively engaged in this line of work. D. W. At-

water, Illuminating Engineer, Westinghouse Lamp Co., Pittsburgh, Pa., will deliver a paper on "Pageant and Spectacular Illumination." This paper will be illustrated by a series of demonstrations using apparatus which has been made up for that purpose. Mr. Atwater, has several trunks full of equipment which he takes around to various places to illustrate how desired results in this special field of illuminating engineering may be accomplished.

The Dix River Hydroelectric Development

The highest rock-filled dam in the world, is the principal feature of the Dix River Hydro-Electric Development which will be described by its designer, L. F. Harza, M. W. S. E., at our meeting April 27. This project is just now being completed as the dam was closed two weeks ago and is now impounding the water so that when the station is ready to be put into operation, there will be plenty of power available.

In preparing this paper Mr. Harza has compiled a most complete and perhaps the only bibliography on rock-filled dams. He has devoted an enormous amount of work to investigation of this subject and has developed a new type of construction.

An interesting part of this meeting will be the motion pictures which will be shown in connection with it. L. E. Meyers Company who have the contract for construction have taken a complete motion picture history of the building of the dam and have kindly consented to allow us to show it at this meeting.

Excursion Over Niles Center Extension

The April Excursion will occur Saturday afternoon, April 11, when a special train will take the members of the Society over the recently completed Niles Center Extension of the Chicago Rapid Transit Lines, which has just been thrown open to traffic. A special train will leave the Howard Street Terminal at 2:00 p. m. and make stops to permit inspection of a number of interesting things to be seen along the way. The subway under the C. & N. W. Ry. tracks was built in zero weather and involves some rather heavy concrete construction. A new bridge has been constructed over the North Shore Channel of the Sanitary District. A stop will be made at this point to inspect it. Another point of special interest is the new automatic substation which supplies power to this five mile branch. Engineers of the Rapid Transit Lines and representatives of the contractors will accompany the party.

Will Hear Accounts of Storm Damage In Illinois

The recent tornado in Southern Illinois will furnish a topic for two meetings early in April, which will undoubtedly be of considerable interest because of the studies that engineers will make to determine better measures to prevent destruction by similar storms in the future.

Our Noonday Luncheon, Friday, April 3rd, will be addressed by Dr. H. W. Gentles, Director, First Aid and Life Saving, Chicago Chapter, American Red Cross. Dr. Gentles will describe the organization maintained by the Red Cross for immediate relief in case of disaster. He will tell how that organization would function in case a disaster should occur in Chicago. Immediately upon receiving news of the tornado in Southern Illinois he took charge of the relief there. He has been through some remarkable experiences and has had an opportunity to observe many of the queer freaks of this and other storms.

The other meeting referred to is that of the Young Men's Forum on Wednesday, April 8, when Harry F. Ferguson, Chief Sanitary Engineer, State Department of Health, will give an address on "Observations and Duties of a Sanitary Engineer in the Tornado Area." As chief sanitary engineer of the State Health Department it fell to the lot of Mr. Ferguson to oversee the precautions that were taken to prevent an epidemic following the enormous destruction of property which included waterworks as well as private property. In such a situation the sanitary precautions must be rigidly enforced. If an epidemic of disease transmitted through drinking water or by

other means should gain headway, the results would be appalling. Here an engineer plays a truly important part.

Mr. Ferguson will have a number of interesting personal experiences to relate which should give us a good first hand picture of the damage done and the conditions which must be met in rebuilding that part of the State.

See How Bread Is Baked

Members of the Society and their ladies will have an unusual opportunity to inspect the school and laboratories of the American School of Baking on Thursday evening, April 6th, at 8 o'clock.

The Institute is conducted by the American Bakers' Association, under the direction of Dr. H. E. Barnard, for scientific research and education in the manufacture of bread and rolls. Dr. Barnard will be remembered by many engineers for his work in sanitation and bacteriology for the State of Indiana. He has arranged to have the laboratories and shops open and running that evening especially for our convenience so that we may see the remarkable progress that has been made in scientific methods of bread production.

The program outlined contemplates assembling the party in the lecture hall for a few short talks on what the institute is and does, the work of the Institute laboratories, the work of the School of Baking, nutrition, baker's service, etc., by the different members of the staff. These short talks of explanation will be followed by a trip through the research, bacteriological and nutrition laboratories and through the bake shop where the latest methods and equipment for bread production will be in operation.

This is a special privilege extended to our members and their ladies to visit the American Institute of Baking at 1135 Fullteron Avenue (two blocks west of the "L" station) on Thursday, April 16 at 8:00 P. M. This trip has been arranged by the Executive Committee of the Young Men's Forum.

Modern Creamery Inspected

The Young Men's Forum continues to live up to its reputation for finding interesting places to visit on its excursions as was evidenced by their trip to the Blue Valley Creamery Co., at Jackson Blvd. and Racine Ave., Chicago.

This Company is the largest exclusive manufacturer of creamery butter in the world, having about 20 factories located throughout the middle west. This plant is the newest one, having been completed only a few months ago. It represents the last word in creamery practice. Cream comes direct from the farms in all kinds and conditions. In order to make it uniform for churning all cream is pasteurized which removes the desirable as well as undesirable bacteria. From the pasteurizer the cream goes through a vacuum device which tempers it and takes out all flavors of weeds, onions, etc. that may have been eaten by the cows and transmitted to the cream. From this machine it goes to a storage vat where a culture is introduced to create the proper degree of acidity by inoculating it with the desired kind of bacteria. The cream is then ready for churning. The butter is taken from the churn to a cooling room where it is made ready for the wrapping machine which wraps it into packages. These wrapping machines are marvels of mechanical ingenuity, two machines now doing the work formerly done by 65 girls.

At every point throughout this process the most accurate control is maintained. All the air in the building is maintained at a constant temperature and constant humidity by means of an elaborate ventilating and air washing system. The product is constantly studied and analyzed to insure uniformity.

It would require more space than can be devoted in this article to describe all of the details of the apparatus inspected, but the members who went on this excursion were impressed with the fact that there was more real engineering and designing in this plant than they have ever thought would be required. The research laboratory was a point of special interest because of its

complete equipment as well as the scientific care that is used in the analysis of the many things, which are studied there.

The Young Men's Forum has discovered a place that would be worth an excursion for the entire society.

Review Street Traffic Regulation

Street traffic regulation by Light Signals was the subject of a meeting held jointly with the Chicago Section, Illuminating Engineering Society on the evening of March 2 in the Society's rooms. This was a discussion in which several speakers participated. H. T. Ilgner, Engineer, Bureau of Electrical Service, City of Milwaukee, contributed the principle discussion which he illustrated liberally with lantern slides.

Mr. Ilgner gave a comprehensive history of the different types of traffic signals that have been used in Milwaukee, extending over a period of several years. He analyzed the advantages and defects of each of the types shown and told how the various difficulties were overcome. Their conclusion led to the general adoption of a pole type signal placed on the right hand curb at a height of about 8 feet above the pavement. Their experience showed them the desirability of adopting a uniform signal indication, as well as uniform location so that motor car drivers would not become confused. This relates particularly to the "Stop-and-Go" Signal, used for regulating the flow of traffic.

The ordinary types of warning signal such as are placed at street intersections were discussed in the same manner. Here also a number of different types have been built and improvements made until the one most satisfactory has been adopted.

There was a frank discussion of traffic signals used in Chicago by several interested members and guests. The principle point of difference seems to be the adoption of synchronized traffic signal in the loop district. All agreed that some kind of co-ordinated system should be adopted but differed as to the details. There were several constructive suggestions submitted.

Electrified I. C. R. R. Terminal Described

D. J. Brumley, (M. W. S. E.) Chief Engineer, Chicago Terminal Improvements, Illinois Central R. R. Co. gave a complete description of the new Illinois Central Terminal at the Lake front and Roosevelt Road at our meeting, Tuesday, March 10 which was attended by an audience that filled our rooms to capacity. Mr. Brumley gave a complete historical account of the Terminal facilities of the Illinois Central R. R. in Chicago, beginning with its charter granted by the General Assembly of the State of Illinois in 1851.

He described the bitter fight that was waged in Chicago over the question of giving the new railroad company a tract of land along the lake front. This location was selected because the Railroad Company in order to protect its property would be obliged to build breakwaters and protective work and thus relieve the taxpayers of heavy expenses which were required in other parts of the city for shore protection. As the city has grown this obligation for constructing and maintaining shore protection has been extended.

As the demand for parks and playgrounds along the Lake front became more urgent a new agreement was entered into between the railroad company and the South Park Commissioners whereby the latter are given the right to reclaim park areas east of the right of way of the railroad. This was confirmed by an ordinance in 1919. The work of reclaiming these park areas is now in progress.

There are 13 major projects which the railroad company is undertaking. The one which has attracted the most popular interest is the change of the method of propulsion from steam to electric. The complete description of this work will be found in Mr. Brumley's paper which will appear in an early issue.

Involved in this new terminal project is the entire rebuilding of the Company's lines for a distance of about 30 miles and the construction of new terminals for both freight and passenger

traffic. Each of these operations was described by Mr. Brumley. In preparation for electric operation the engineers of the Railroad Company conducted an extensive study of electric transportation systems all over the world. As a result of this study it was decided to use direct current at 1500 volts supplied through an overhead trolley. Power will be purchased from the Commonwealth Edison Co. which will install and operate seven substations. The suburban passenger service will be the first to be electrified and will require approximately 55 million kw.-hrs. per annum. This new service will be an average of 18 to 20 per cent faster than the present service rendered by steam locomotives.

This meeting was held on Tuesday evening in order to permit visiting engineers who were in attendance at the Annual Convention of the American Railway Engineering Association to attend. There were a large number of guests present.

Gas Plant Requires Study

"Some Engineering Features of a Modern Gas Plant" was the title of a paper read before the Society, Tuesday, March 17, by H. E. Bates, M. W. S. E. Asst. Chief Engineer, Peoples Gas Light & Coke Co., Chicago.

This paper was a comprehensive analysis of the different kinds of gas plants that have been developed and the factors recommending each of them for a particular kind of service. Mr. Bates gave a considerable amount of attention to the economic factors which determine the particular kind of gas plants to be used in different conditions.

Governmental regulation frequently determines the kind of plant that must be installed to secure a required candle power or a given heating value. For example the City of Chicago requires a certain standard of candle power or luminosity in the city gas which is obtained by enriching it with oil. This is known as carburetted water gas. The same quantity of heat per cubic feet could be furnished at less cost if it were not necessary to enrich the gas to give it a more luminous flame.

After describing the general conditions and their effect on the type of plant to be selected, Mr. Bates illustrated his conclusions with a complete description of the operation of the new plant in Chicago which is the second largest gas plant in the world. He showed how the principles determined by economic study had been carried out in the design and operation of this plant. There was an interesting discussion of this paper which brought out a great deal of practical information.

Largest Attendance This Year

The biggest meeting this year was held Tuesday, March 24 in Fullerton Hall with the Chicago Section, American Institute of Electrical Engineers, when W. L. R. Emmett, Consulting Engineer, General Electric Co., Schenectady, N. Y., gave an interesting description of the "Mercury-Vapor Boiler and Turbine."

This system has attracted attention all over the world, because of the remarkable economy of heat which may be obtained by its use in the generation of electric power. The speaker was introduced by W. L. Abbott, Past President, W. S. E. who has been a close personal friend for many years.

Mr. Emmett has experimented with this system for more than twenty years, in order to find a substance that would have suitable properties. Mercury met all the requirements best, although there are other substances, such as sulphur and certain oils which have suitable thermodynamic properties.

Mercury is satisfactory if it can be mastered. It is peculiar in that it does not wet the surface of the vessel in which it is contained and therefore boils explosively. Many years of work were required to develop an experimental equipment that would be satisfactory. Finally a small outfit was made and it worked beautifully. A larger one was made on exactly the same principle and was almost a complete failure. However the weaknesses in the larger equipment were remedied and an installation made at Hartford, Conn., which ran for about

a year carrying a load of 1,200 to 1,500 k.w. This has been successful except for the boiler which shows a few minor points of weakness. These are being remedied and the new boiler is expected to operate with entire satisfaction.

Everyhting in the mercury process is different from that in steam. Mercury vapor is most insidious and will find ways to escape where steam or any other gas would be retained. For this reason all joints have to be very carefully welded as such a thing as a threaded connection would be entirely out of the question. This method of construction requires careful provision for expansion.

Briefly stated the principle of this system is that mercury is vaporized in a special boiler and then passed through a single stage turbine where it gives up its power. In condensing the mercury gives up its heat to another boiler generating steam which drives a second turbine. The mercury goes back to the boiler where it is again vaporized. This is repeated from six to ten times per hour in normal operation. None of the mercury is lost.

In comparison with the large unit in the Crawford Ave. Station, Chicago, which attains the highest efficiency yet recorded in Central Station practice, namely 15,000 b. t. u. per k. w.-hr., the mercury turbine develops power for an expenditure of 11,000 b. t. u. per k.w.-hr. Mr. Emmett says that he has assurance from more than a hundred producers of mercury that they can supply all the mercury that will be required to meet the demand. This answers the criticism that there is not enough mercury in the world to equip a large station.

The total attendance was 550.

Interesting Tests Seen at Underwriters Laboratories

There were more than 125 of our members who took time away from business, Friday, March 20 to attend the Excursion to the Underwriters' Laboratories, 207 East Ohio street.

On arrival at the laboratories the members were welcomed in the Reception Room by Assistant Secretary G. T. Bunker, M. W. S. E. who gave a short address telling about the work of the laboratories and outlining the program that would be presented for the instruction of the guests during the afternoon.

First on the program was a demonstration of an Automatic Sprinkler Equipment in one of the upper rooms of the laboratories. A fire was started in this room and promptly extinguished by the Automatic Sprinkler equipment. The party was then divided up into small groups, each being given a guide who explained the tests that were being conducted in the various departments, and showed how the work was done. This work covered a great variety of tests on automotive accessories, sprinklers and domestic oil burners.

The groups were reassembled in the basement to witness the beginning of an actual fire test on a set of hollow metal elevator doors. The doors had been built into a panel in the wall of a special furnace where they were subjected to the flame of a gas fire which brought the door up to a temperature of 1700 degrees F. at the end of an hour. At the conclusion of this period the panel was swung out from the furnace and a stream of water from a fire hose turned on it. This particular specimen withstood the fire successfully for an hour and was not put out of commission by the fire hose.

A special apparatus has been designed to test bumpers for automobiles. This was demonstrated to show that if there were any flaws in the sample, they would certainly have been found out. The next test was the demonstration of a foam extinguisher for putting out gasoline fire which was quite spectacular. A small tank of gasoline was ignited and allowed to burn for 40 seconds. The fire was put out in 41 seconds.

Prof. Charles R. Richards, M. W. S. E., has been appointed by Secretary Hoover to visit the International Exposition of Modern Decorative and Industrial Art in Paris this summer to report such of its features as may be of interest to American manufacturers.

Reports On Chicago Water Supply

Two subcommittees of the Public Affairs Committee have joined in an investigation and report on the sanitary features of the Chicago public water supply system. The following report which summarizes their findings and recommendations was approved by the Board of Direction, March 16, 1925.

Report of the Sub-committees on Health and Sanitation and on Water Supply and Sewage Disposal of the Public Affairs Committee of the Western Society of Engineers:

We find that at the present time water samples are taken and analyses are made by the Health Department. Following such analyses and report by the Sanitary Engineer of the Health Department, the operators of the various pumping stations are instructed as to the chlorine they are to put into the water. Later an inspection at the pump stations is made by inspectors from the Health Department to see that the instructions regarding chlorine dosage have been complied with. Pay for this inspection service comes from the water fund.

The sanitary engineering supervision in the City Health Department is thoroughly competent and the foregoing chlorination procedure fairly efficient.

There is more or less opposition or resentment on the part of pump station operators to the checking up inspection.

The engineering staff in the City Water Department is competent and efficient. In the excessive subdivision of engineering departments in the City Hall, the City Engineer's office has now its principal function in the extension and operation of the city water supply.

Conclusions. We consider that a municipal water department should handle and be responsible for the efficient furnishing of an adequate supply of pure water without divided responsibility.

We recommend that the City Engineer should be assigned the duties of water sampling and analyses and that he be provided with all the necessary laboratory and other facilities.

We consider the check inspection of the pump station operators' chlorine dosage to be very essential and that it should be rigidly maintained under any operation by the City Engineer.

We consider that an investigation for need of any filtration plants as well as their design is a duty of the City Engineer's office and no new department for this purpose is needed.

We consider that the Health Department should have the power and has the duty of examining into the purity of water furnished by the water department at such itmes as it deems advisable and that the Health Department has the duty of investigating into the operations of results of any other municipal departments when the interests of public health are involved.

The need for any additional engineering staff in the City Health Department aside from the foregoing inspection of water supply is a matter for further consideration by the sub-committee on Health and Sanitation and is not pertinent to this report.

Committee on Health and Sanitation.

PAUL HANSEN, Chairman,

Committee on Water Supply and Sewage Disposal.

L. K. SHERMAN, Chairman,

Approved and referred to Board of Direction by Public Affairs Committee (20 present) March 9.

Temple Bill Signed

The Secretary has received the following letter relative to the Temple Bill which has recently been signed:

"In behalf of the Executive Committee of the Association of American State Geologists, it gives me pleasure to inform you that the President has attached his signature to the Temple Bill which provides for the completion of the topographic mapping of the United States. It is also gratifying to acknowledge the most helpful service which was rendered by the Western Society of Engineers during the consideration of this bill by Congress. We enjoyed the co-operation of practically all the engi-

neering societies of note in this country whose members have use for topographic maps, and in addition other technical societies, reclamation associations, drainage organizations, geological societies, state highway officials, Congress of Western Governors, etc., etc., in agitating the favorable consideration of this bill by Congress. This spirit of co-opeartion was most impressive and doubtless will serve as an illustration of how successfully the support of a large number of organizations may be centralized and focused in the accomplishment of a nation-wide scientific project.

"Please accept our most hearty thanks for your valued co-operation.

Very sincerely yours,
ASSOCIATION OF AMERICAN STATE GEOLOGISTS
M. M. Leighton, Sec'y.

Endorses the Traction Ordinance

Following an investigation by the Local Transportation sub-committee of the Public Affairs Committee approved the pending Traction Ordinance in the report given below which was referred to the Board of Direction, which approved it March 16, 1925:

Memorandum to Public Affairs Committee, Western Society of Engineers, from Sub-Committee on Local Transportation:

Present Conditions:

(1) The franchises of the Surface Lines expire February 1, 1927, at which time approximately $140,000,000 of bonds become due and payable.

(2) Under the 20-year franchise limitation it will be impossible to refinance with private capital.

(3) The surface lines, elevated lines and bus lines are all operated independently and in competition with each other, which results in duplication of service and waste.

(4) Necessary expansion of existing properties by private capital would require statutory changes so as to enable the City to grant indeterminate franchises which would involve considerable delay.

(5) The only plan now under consideration for public financing of transportation facilities in Chicago is the Municipal Railway Certificate Plan as embodied in the ordinance recently passed by the City Council, however, a transportation district plan which failed to pass at the last session of the Legislature has again been urged by Governor Small.

Provisions of the Ordinance:

The ordinance now before the public provides:

(1) For the acquisition of the existing surface and elevated lines;

(2) For the construction of much-needed extensions of both surface and rapid transit lines;

(3) For the construction of subways where essential to the development of an adequate transportation system;

(4) For the purchase and operation of bus lines if approved at a subsequent referendum;

(5) For financing of the purchases and construction above outlined by means of income certificates payable SOLELY from earnings of the properties at a lower rate of interest than is otherwise possible;

(6) For the creation of a non-political Railway Board to manage the properties, which will be free from interference by the City Council and State;

(7) For service at cost and universal transfer;

(8) No funds can be raised by taxation and used to pay the interest, principal of the certificates, or to make up deficits, should there be any, in the operation of the properties; and

(9) For the final removal of traction from politics.

Recommendation:

In consideration of the foregoing it is recommended that the Western Society of Engineers approve the adoption of "An Ordinance Providing for a Comprehensive Municipal Local Transportation System" as passed by the City Council on February 27th, 1925, and that the Society recommend to its mem-

bers and to the citizens of Chicago that they support the Ordinance at the election to be held April 7th, 1925.

C. E. DE LEUW, Chairman.
Sub-Committe on Local Transportation.
Approved by Public Affairs Committee and referred to Board of Direction, March 9, 1925. 15 ayes, 1 no.

Section Officers for Next Year

Nominations for officers for all of the sections of the Society have now been completed in accordance with the Constitution. The following have been nominated for the officers in the Sections for the ensuing year:

Mechanical Section
Chairman—D. Levinger.
Vice Chairman—T. A. March.
Director 3 yrs.—E. F. Rich.

Hydraulic, Sanitary and Municipal Section
Chairman—John A. Dailey.
Vice Chairman—Geo. H. Tillson.
Director 3 yrs.—Paul Hansen.

Illuminating Engineering Section
Chairman—Fred A. Rogers.
Vice Chairman—E. J. Teberg.
Director 1 yr.—A. L. Arenberg, (Succeeding Mr. Teberg).
Director 2 yrs.—A. Herz (Succeeding A. H. Gerald).
Director 3 yrs.—J. J. Kirk.

Railroad Engineering Section
Chairman—C. P. Richardson.
Vice Chairman—C. H. Mottier.
Director 3 yrs.—J. de N. Macomb.

Telephone, Telegraph and Radio Section
Chairman—F. R. Quayle.
Vice Chairman—J. H. Riley.
Director 3 yrs.—F. E. Goodnow.

Gas Engineering Section
Chairman—C. A. Schnerr.
Vice Chairman—E. H. Enander.
Director 3 yrs.—C. H. Kallstedt.

Electrical Section
Chairman—Carl Lee.
Vice Chairman—K. A. Auty.
Director 3 yrs.—William Wurth.

Bridge and Structural Engineering Section.
Chairman—F. G. Vent.
Vice-Chairman—Prof. John C. Penn.
Director 3 yrs.—W. A. Rogers.

The elections will be held according to the schedule published in the February Journal.

Officers Nominated

The Constitution of the Western Society of Engineers specifies that nominations for officers shall be made by a Nominating Committee appointed at the January meeting of the Board of Direction. The report of that Committee was received at the March meeting of the Board placing the following in nomination:

President—Homer E. Niesz.

1st Vice President—F. E. Morrow.

2nd Vice President—R. W. Putnam.

3rd Vice President—John A. Garcia.

Treasurer—Geo. W. Hand.

Trustee for 3 yrs.—Frank D. Chase.

Members of the Washington Award Committee—E. T. Howson and R. F. Schuchardt.

The Constitution further provides that additional nominations may be made by petition signed by twenty corporate members and accompanied by the acceptance of the nominees if such petition is presented to the Secretary before the 20th day of April. Individual notice of the nominations submitted by the Nominating Committee has been sent to each member of the Society.

John Fritz Medal Awarded to John F. Stevens

The John Fritz Gold Medal which was awarded in January to Mr. John F. Stevens for great achievements as a civil engineer, particularly in planning and organizing for the construction of the Panama Canal; as a builder of railroads, and as administrator of the Chinese Eastern and Siberian Railway, was presented with suitable ceremony in the Auditorium of Engineering Societies Building (New York) at 8:30 P. M., Monday March 23. The speakers were Mr. Ralph Budd, President of the Great Northern Railway, and Honorable Roland S. Morris, formerly Ambassador to Japan. Mr. John R. Freeman, member of the John Fritz Board of Award, was the chairman of the evening.

An Opportunity for Engineers

There comes to the editor's office an announcement which should appeal to a considerable number of our members. Bonbright & Co. of 25 Nassau St., New York have offered prizes aggregating $10,000 for the best contemporary review and forecast of the electric light and power industry, covering the decade 1920-1930. These prizes range from $5,000 for first prize down to $100.00. The competition is to close May 18, 1925. It will in effect be five years of history and five years forecast. There is a suplementary award, that is even more interesting. The American Superpower Corporation has authorized another prize of $10,000 to be awarded to that contestant whose paper again reviewed in 1930 shall appear to have most nearly approximated the facts as they develope. This prize will be awarded as shortly after January 1, 1930 as is possible. Certainly it would be worth considerable time and study to prepare an article, which would have a chance of winning a $5,000 prize now and a $10,000 one in five years. The editor will be glad to give any of our members more information about this contest, if they will call at the office.

Chicago Engineers Honored

Engineering Foundation has appointed 200 engineers in all parts of the country to represent it in prosecuting a nation wide plan of research "for the furtherance of research in science and engineering and the good of mankind." There are sixteen engineers appointed from Chicago and it is gratifying to the Western Society of Engineers to note that every one of the men selected is a member of this Society. The Chicago representatives are: Mortimer G. Barnes, Division of Waterways, 1404 Kimball Building; John Brunner, Illinois Steel Company, 208 S. La Salle St.; Horace Carpenter, The Arnold Engineering Company, 565 W. Washington Blvd.; Wharton Clay, Association of Metal Lath Manufacturers, 123 W. Madison St.; W. W. DeBerard, Engineering-News-Record, 1570 Old Colony Bldg.; E. T. Howson, Railway Age, 750 Transportation Bldg.; William M. Kinney, Portland Cement Association; 111 W. Washington St.; Frank B. Knight, Lidgerwood Manufacturing Company, 1917 Fisher Bldg.; A. E. Lindau, American System of Reinforcing, 10 S. La Salle St.; Virgil G. Marani, the Gypsum Industries, 344 Rush St.; Montford Morrison, Acme-International X-Ray Company, 341 W. Chicago Ave.; Edgar S. Nethercut, Western Society of Engineers, 53 W. Jackson Blvd.; Frank Rasmussen, Link-Belt Co.; 300 W. Thirty-ninth St., Arthur L. Rice, Power Plant Engineering, 537 S. Dearborn St.; H. R. Safford, Chicago, Burlington & Quincy R. R., 547 W. Jackson Blvd.; J. W. Woermann, Northwestern Division, United States Engineer Office, 537 S. Dearborn St.

RESEARCH FELLOWSHIPS IN METALLURGY AND MINING OFFERED

In co-operation with the United States Bureau of Mines and the State Mining Experiment Station, the School of Mines and Metallurgy of the University of Missouri offers four fellowships. These fellowships are open to graduates who have the equivalent of a Bachelor of Science degree and have had the proper training in mining, metallurgy, or chemistry, and who are qualified to undertake research work. The income of each fellowship is $800 per annum for the twelve months beginning July 1, 1925. Fellows pay fees amounting to approximately $30 per year.

Fellows will register as students in the School of Mines and Metallurgy of the University of Missouri, and become candidates for the degree of Master of Science (unless this or an equivalent degree has been earned.) Their class work will be directed by the heads of the departments of instruction, but the greater portion of their time will be spent in research work under the direction of the Bureau of Mines staff resident at the School of Mines. The purpose of this work is to undertake the solution of definite problems confronting the mining and metallurgical industries of the State of Missouri. For 1925-26

the four fellowships will be granted in the following subjects:

Metallurgy of Zinc, Refractories for Metallurgy of Zinc, Physical Metallurgy (heat treatment of steel.)

Applications, with a certified copy of collegiate record, statement of professional experience, and names and addresses of three references will be received up to June 15, 1925. The application should be addressed to the Director, School of Mines and Metallurgy, University of Missouri, Rolla, Missouri.

Notes from the Library

NEW REFERENCE BOOKS

624.08
K22s3
Structural engineers' handbook.
By Milo S. Ketchum. 3rd ed. enlarged. N. Y., McGraw, 1924. 1065 p. Tables, diagrs.

In this edition the book has been revised and partially rewritten — more than 130 pages of new material has been added. The most important additions are: Design of self-supporting steel stacks; steel column footings; and the American Institute of Steel Construction's Specifications for structural steel for buildings. Tables and standards have been brought up to date. New material has been added on steel mill buildings, steel office buildings steel and timber highway bridges, steel railway bridges, electric traveling cranes, and retaining walls. The sections on stresses in stiff frames and in eccentric riveted connections have additional data.

621.08
K37m10
Mechanical engineers' handbook.
By William Kent. 10th ed. rewritten by R. T. Kent and a staff of specialists. N. Y., Wiley 1923. 2247p. Tables, diagrs.

A standard handbook containing new material and new tables in this edition. The sections on fans and blowers, hydraulic turbines, pumps and pumping engines, oil engines and gas producers, refrigeration, heating and ventilation have been rewritten. New sections include gas turbines, automobile vehicles, aeronautics, fusion welding and cutting, malleable casting, reinforced concrete, and safety engineering.

697
H441d
Data sheets on heating and ventilation.
N. Y., Heating and Ventlating Magazine, 1924. Loose leaf tables.

A handbook containing in table form innumerable computation required daily by the heating and ventilating engineer. A few of the subjects covered are: B. T. U. losses, air changes, radiation computation, sizes of ducts and flues, chimneys, flow of steam, pipe covering, steam heating, vapor heating, and water heating. The loose leaf form allows for constant revision and addition.

Chicago Daily News Almanac and Yearbook for 1925.
Ed. by James Langland. Chicago Daily News, 1924. 1024 p.

Book Notices

NEW ELECTRICAL BOOKS

621.313
C941e1
Electrical machinery and control diagrams.
By Terrell Croft, N. Y. McGraw, 1924. 305 p. Diagrs.

A collection of 500 circuit diagrams representing all of the apparatus ordinarily used in modern electric power practice: alternating and direct current generators, transformers, synchronous converters, control apparatus, instruments, etc. Only such supplementary text is given as is necessary to explain the diagrams.

621.319
C941C
Conduit wiring.
By Terrell Croft. N. Y. McGraw, 1924. 458 p. Illus., diagrs.

A detailed exposition of the conduit method of interior wiring. The steps and operations which must be followed in installing jobs of all kinds from small ones in residences to those in the largest office buildings and industrial plants are discussed clearly with accompanying illustrations and diagrams. Conduit wiring in reinforced concrete structures is given special attention.

621.328
C941w4
Wiring for light and power.
By Terrell Croft. 4th ed. N. Y. McGraw, 1924. 551 p. Illus., tables, diagrs.

Completely rewritten and revised to conform with the rearrangements and changes in the 1923 National Electric Code. Describes the installation of wiring and apparatus for practically all services.

621.33
R529e2
Electric railway handbook.
By A. S. Richey. 2d ed. N. Y. McGraw, 1924. 798 p. Illus. tables, diagrs.

A revision of this standard handbook necessitated by the rapid changes occurring in electric railway practice. The material treated includes: roadbed and track; car houses and shops; train movement; railway motors; controlling apparatus; collecting devices; trucks; braking; cars; transmission and distribution; and signals and communication.

621.373
N277h4
Handbook for electric metermen.
By the Meter Committee of the Technical National Section of the N. E. L. A. 4th ed. N. Y., 1924. 1242 p. Illus., tables, diagrs

The purpose of the handbook is purely educational. It has been prepared primarily as an aid to the practicing meterman, and the meter engineer. In it have been included instructions, descriptions, data and information, which every meterman should have at hand for ready reference. Much of the material appearing in previous issues has been condensed, obsolete data and descriptions have been omitted and new material has been added. The subject matter has been limited to American meters and to American meter practice, and an endeavor has been made to standardize meter terminology.

The chapters have been arranged in a logical sequence of theory, application, description, methods, records, and general information. The descriptive data on meters include certain types no longer manufactured, but of which there are

many still in use. Separate chapters for each manufacturer appear in a group followed by chapters on rotating standards, demand meters, and switchboard instruments.

621.328
C9411
Lighting circuits and switches.
By Terrell Croft. N. Y. McGraw, 1923. 472 p. Illus., diagrs.

A reference book consisting largely of diagrams and drawings supplemented by explanatory text. The material relates almost wholly to electric and lighting circuits for interior building applications operating on low potential systems. Most of the matter concerns 110-220, two or three wire systems. The introductory material is followed by chapters on the different types of circuits. The final division consists of a 40 page article on theatre lighting which has become a subject of considerable complexity.

537.1
M654e2
The electron; its isolation and measurement and the determination of some of its properties.
By R. A. Millikan. 2d ed. Chicago, U. of C. Press, 1924. 293 p. Illus., tables, diagrs.

A revision of Millikan's earlier well known, semi-popular treatise on the electron with the additions and modifications brought about by seven years' progress in physics. To retain a simple treatment all mathematical proofs have been placed in the appendices. The volume begins with an historical discussion of electrical theories; gives a general proof of the atomic nature of electricity and the exact valuation of e; finally dealing with the structure of the atom and the nature of radiant energy.

621.313
S823th
Theory and calculations of electrical apparatus.
By C. P. Steinmetz. N. Y. McGraw, 1917. 480 p. Diagrs.

A discussion of electrical apparatus under the following headings: speed control of induction motors; concatenation; induction motor regulation and stability; higher harmonics in induction motors; synchronous induction generator; phase conversion and single phase generation; a.-c. motors in general; single phase commutator motors; unipolar machines; etc.

621.3
S823th
Theory and calculation of electric circuits.
By C. P. Steinmetz. N. Y. McGraw, 1917. 361 p. Illus., diagrs.

Discusses the most important characteristics of the fundamental conception of electrical engineering, such as electric conduction, magnetism, wave shape, the meaning of reactance and similar terms, the problems of stability and instability of electric systems, etc.

Additions to the Library

Canada. Dept. of Mines. Mining laws of Canada. 1924.

Carnegie Institution of Washington. Yearbook. v. 23. 1924.

Chicago. Dept. of Public Works. Annual report. v. 48. 1923.

Engineering Assn. of Malaya. Transactions. v. 3. 1924.

Illinois Engineering Experiment Station. Bulletins 135-142; Circular 10. 1924.

Institution of Engineers and Shipbuilders in Scotland. Transactions. v. 67. 1924.

Massachusetts. Dept. of Public Health. Annual report. 1923.

New York. Transit Commission. Annual report. 1922.

New York. Transit Commission. Summary of the annual report. 1924.

U. S. Engineer Dept. Annual report. 1921-1924. 9v.

U. S. National Advisory Committee for Aeronautics. Annual report. 1924.

U. S. Public Health Service. A study of the pollution and natural purification of the Ohio River. II. Report on surveys and laboratory studies. 1924.

Our library is compiling a very interesting file of data describing the work of American Engineering Standards Committee which is made up of representatives of practically every technical and industrial group in this country, as well as government departments and the Army and Navy. The work of this committee is so broad that it could not be described in the space of a short article, but it is safe to say that it covers nearly every field of manufacture. Savings in industry, due to the elimination of sizes and models infrequently used amount to untold millions of dollars annually. This is a part of the work of the Engineering Standards Committee.

Personals

The Board of Directors of the New England Mills Company announce the election of Albert L. Arenberg, M. W. S. E., as president.

The Company which was established in 1912 will continue as wholesalers and distributors of automobile accesssories, tires and radio apparatus, at 849 W. Washington Blvd., Chicago. Activities of the radio division will be enlarged thru the addition of salesmen and radio engineers calling on the dealer trade.

P. Albert Poppenhusen, M. W. S. E., who, for 27 years was President of the Green Engineering Co., has re-entered the power plant equipment field. It will be remembered that the International Combustion Corporation acquired the Green Engineering Co., from Mr. Poppenhusen about two years ago.

Ralph C. Acers, Earl Acers, and P. Albert Poppenhusen, under the firm name of Acers & Poppenhusen are representing The Engineer Co., Proco Products and other power plant equipment manufacturers.

Their offices are at 622 McCormick Bldg.

The following is a letter received from one of our members in appreciation of the new membership certificate, which has recently been issued to those who applied for it.

My dear Mr. Nethercut:

I am writing to thank you and the Society for my diploma which I received yesterday neatly framed, and I want to compliment the Society and the Committee in charge, for its neat and dignified appearance.

Thanking you for past courtesies and wishing you and the Society continued success, I remain

Very truly yours,
(Signed) P. S. COMBS.

W. F. Hosford, M. W. S. E., Superintendent of Development, Western Electric Co., has been appointed to a new position created for the purpose of general supervision over engineering work, conducted by the Company. Mr. Hosford will report directly to the Vice President. He will be stationed in New York, where he expects to move as soon as possible. We will regret to see him leave Chicago as he has been one of our faithful workers in the Society. He has been Chairman of our Telephone, Telegraph and Radio Section, during the year just coming to a close. D. Levinger, M. W. S. E., has been appointed his successor, as Superintendent of Development at Hawthorne Works. The best wishes of the Society are extended to Messrs. Hosford and Levinger in their new positions.

JOHN F. HAYFORD

John F. Hayford, M. W. S. E. well known scientist, engineer and mathematician died at his home, 1124 Judson Avenue, Evanston, Ill., March 10, 1925.

Prof. Hayford was born in Rouse's Point, N. Y., May 19, 1868, and graduated as a civil engineer from Cornell University. His first connection was with the United States coast and geodetic survey. Some years later he was appointed chairman of a commission to settle a boundary dispute between Costa Rica and Panama, and he went into the jungle with a surveying party and chopped his way, fighting snakes and fever, through the tropical forest. He was also a member of the party which established the boundary line between Alaska and Canada.

Prof. Hayford had been director of the college of engineering at Northwestern since September 1, 1909. He was a member of the National Advisory Committee for Aeronautics, a fellow of the A. A. A. S., member of the National Academy of Sciences, the American Philosophical Society, the American Astronomical Society, the American Society of Civil Engineers, the Western Society of Engineers and of the Research Association of Carnegie Institution.

He is survived by his widow and four children—Phyllis, who is a junior in the college of engineering at Evanston, Max and John B. Hayford, graduates of that college and Walter, who lives in Yonkers, N. Y.

It will be recalled that Prof. Hayford, read a paper before the Society last Spring, explaining his theory as to the proof of the condition of isostasy or equal static pressure in the interior of the earth.

Prof. Hayford has been ill since early in January. On the day before his death, word was received that the International Geodetic and Physical Union meeting in Madrid, Spain had adopted his measurements of the size and the shape of the earth as standard for scientific purposes throughout the world. He received the Victoria medal of the

Royal Geographic Society of Great Britain last spring for his work on the theory of isostasy. The presentation was made in London, through the American ambassador. At the same time when that event was occurring there he read his paper on isostasy before the Western Society. This has been published in our Journal.

Prof. Hayford's most recent work has been in connection with the measurement of the mean levels of the Great Lakes and a determination of the loss by evaporation. He has been engaged on this for the past fourteen years and the work is not yet completed.

We will miss Prof. Hayford at the meetings of this Society where his discussion of engineering subjects was always welcome.

NEW MEMBERS

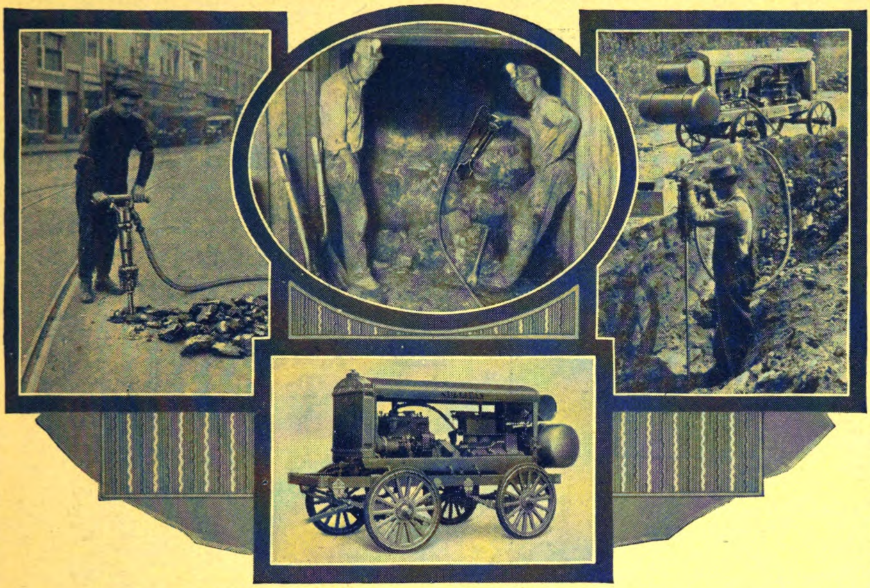
The following were elected to membership in the grade shown by the Board of Direction at its meeting February 16, 1925:

No.	Name	Address	Grade
430—1924	A. F. Gramse	1334 Wisconsin Ave., Oak Park, Ill.	Associate
495—1924	Vincent W. O'Donnel	6217 Kimbark Ave., Chicago, Ill.	Student
516	James N. Dalton	7800 Burnham Ave., Chicago, Ill.	Student
518	Edward Slodowski	1936 S. 49th Ave., Cicero, Ill.	Student
542	Wm. M. Nichols	Box 183, Angola, Ind.	Student
554	Anton S. Rosing	% Armco Culvert & Flume Mfgr. Assn. Middletown, Ohio	Member
560	Richard T. McKay	119 E. 59th St., Chicago, Ill.	Associate
561	Herbert B. Fay	Box 182, Angola, Ind.	Student
1—1925	Edward W. Prentiss	4030 N. Paulina St., Chicago, Ill.	Junior
2	Theodore W. Miller	1524 Monadnock Block, Chicago, Ill.	Junior
4—1925	Frank R. Johnson	2706 S. Michigan Ave., Chicago, Ill.	Student
5	Walter E. Ramus	1733 Gregory St., Chicago, Ill.	Associate
6	Jorge Maroto	3935 W. Monroe St., Chicago, Ill.	Junior
7	John B. Millis	Byron, Ill.	Affiliate
9	Felix Z. Tiongco	6245 Kenwood Ave., Chicago, Ill.	Student
10	John W. Leppan	5778 Portage Ave., Chicago, Ill.	Associate
12	A. W. Seels	10535 Prospect Ave., Chicago, Ill.	Junior

APPLICATIONS FOR MEMBERSHIP

Members of the Society can be of great service if they will make a practice of examining the list of applicants published herewith and promptly notifying the Membership Committee or the Secretary regarding the qualifications of any of those whose names appear on the list. The Society desires to extend its membership and receive those engineers who have the proper qualifications and wish to participate in its activities. The following applications have been received since last report:

No.	Name	Address
13—1925	Robt. M. Barnes, Jr.	310 Gary Ave., Wheaton, Ill.
14	Allen L. Kukral	3257 S. Michigan Ave., Chicago, Ill.
15	Joseph Klecka	711 Diversey Pkw. Chicago, Ill.
16	William D. Shipman	Franklin Park, Ill.
17	Warren J. Siegfried	3322 S. Michigan Ave., Chicago, Ill.
18	E. W. Bell	4550 Lake Park Ave., Chicago, Ill.
19	F. W. Russell	1717 E. 67th St., Chicago, Ill.
20	A. R. Kipp	123 W. Madison St., Chicago, Ill.
21	Guy W. Connell	6018 Kenwood Ave., Chicago, Ill.
22	A. J. Connelly	58 W. Randolph St., Chicago, Ill.
23	T. T. Landhy	1421 Norwood St., Chicago, Ill.
24	Jas. C. Trueman	5714 Blackstone Ave., Chicago, Ill.
25	Andrew Lebailly	1026 N. State St., Chicago, Ill.
26	Raymond J. Traham, Trsf.	30 N. Michigan Ave., Chicago, Ill.
27	John F. Little	5648 W. 65th St., Chicago, Ill.
28	E. C. Hach	1834 S. 48th Court, Cicero, Ill.
29	Wm. C. Stammer	415 S. Darling St., Angola, Ind.



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THE CLOSE OF A GOOD YEAR

May is the last month of technical meetings before the summer vacation. We have had a wonderful year as far as our technical program is concerned and the meetings arranged for the last month show no indication of letting down in the standard that has been maintained. The attendance to date has been far ahead of any previous year which is a direct reflection of the quality of material which has been presented. Attention is called to the announcement of May meetings as contained in the following paragraphs.

"The Castleton-Cutoff"

W. F. Jordan, Prin. Asst. Engr. N. Y. C. R. R. Co., Albany, N. Y. will be our speaker on Tuesday, May 5. His subject will be the "Hudson River Connecting Railroad." (Castleton-Cutoff). Mr. Jordan was directly in charge of the construction of this enormous project which has been in contemplation for almost a quarter of a century. The crossing of the Hudson River at Albany, N. Y. is the "neck of the bottle" in the New York Central Lines. The drawbridge at this point is the second bridge across the Hudson above its outlet at New York, the other one being at Poughkeepsie. This is a low level bridge which is open about eight hours out of every twenty-four to permit river traffic to pass. The terminals at Albany were badly overcrowded and the long steep grades necessitated the breaking up of heavy trains and the addition of expensive pusher service. To overcome these conditions a high-level cut-off over twenty miles in length was projected. The total cost was in excess of 20 million dollars, but it relieves one of the heaviest traffic sections in the world.

Two of the outstanding features in the project are the Selkirk Yard, six miles long and with a total ultimate capacity of 23,000 cars and the Alfred H. Smith Memorial Bridge over the Hudson which is a mile long and includes one span of 600 ft. and one of 400 ft. In an undertaking of this kind there are many other features which of themselves would be considered large, as for example some of the concrete culverts and some of the excavating and filling that was necessary.

Mr. Jordan will illustrate his address with a number of large maps and lantern slides.

Engineering and the Public Service

Maj. Alexander Forward, Secy-Manager, American Gas Association, New York will be the speaker on Monday, May 11. His subject will be "Engineering and the Public Service."

Maj. Forward in his years of association with the public utility engineers and managers in the American Gas Association has conceived a high opinion of the value of engineering service in public utilities. He has a wide acquaintance in this field. His address is full of interesting observations which are an inspiration to engineers in whatever line of endeavor they may be engaged.

Protective Relays

One of the important elements in any electrical installation is the matter of the protection of the apparatus. This is a feature which cannot be overlooked and one that requires the most careful attention.

O. J. Bliss, Assistant Chief Testing Engineer, Commonwealth Edison Co. will be the speaker on Monday, May 18 at a joint meeting with the Chicago Section, American Institute of Electrical Engineers. Mr. Bliss will take for his subject "Protective Relays." In this he is a specialist

as he has devoted years of study to the investigation of all sorts of protective devices. It is said that he is probably one of the best posted men in this country on this subject.

This paper will present the results of the very careful and extended researches that have been made by the Commonwealth Edison Co. to discover the kind of protective aparatus that is best adapted for the many different kinds of service connected to this system.

Engineers having to do with electrical apparatus in any of its uses, particularly in power distribution, cannot well afford to overlook this meeting.

Reports on Tornado Damage

The last technical meeting of the month and of the present fiscal year occurs Monday, May 25. This will be in the form of a report by the members of the Executive Committee, Bridge& Structural Section presenting the results of their investigation of the damage done to structures by the recent tornado in southern Illinois.

This will not be an ordinary, dry report but is a real story full of constructive material and extremely interesting. The members of the Executive Committee made a special trip into southern Illinois immediately after the tornado for the purposes of studying all remaining evidence to observe the kinds of construction which best withstood the effects of the storm and, if possible, of suggesting types of construction which would offer better resistance. They took about a hundred photographs, many of which will be used to illustrate this report and all of which will be on exhibition. Military passes were provided so that they would have free acess to any parts which they wished to study and every facility was placed at their disposal by the authorities.

As a result of their observation the committee has evolved certain changes in structural designs which can be made at moderate cost but which will add greatly to the strength and stability of the buildings. These suggestions will be presented in a tentative form in this report, supported by the evidence which indicates the need for such construction. Briefly stated it may be said that the principal requirement is for better anchorages to foundations and better connection of roof to side walls. Aside from the many valuable technical observations the committee had some interesting personal experiences which will be described as a matter of general interest. As far as it is known this is the first systematic study and report of this nature ever presented by an engineering society. The release of this report is being waited with a great deal of interest.

Zuppke to Speak at Forum

The climax of the activities of our Young Men's Forum for this year will occur Wednesday, May 6th at their second Annual Dinner to be held at the City Club, 315 Plymouth Court.

The Forum believes in doing things right. Last year they succeeded in getting a speaker for their dinner, who was very much in demand and at the same time almost impossible to secure, but they got him. This year the speaker will be a man who is known throughout the athletic world. Robert C. Zuppke, the famous football coach of the University of Illinois, will speak on "Intercollegiate Contests—Why They Persist." The subject itself is one which interests every man who has ever attended a college. The speaker is a man whose ideas are always respected. His success in building up winning football teams has been phenomenal.

Robert Carr, President, Dearborn Chemical Co., will act as toastmaster. Mr. Carr was a famous athlete in his college days and in later years has taken very keen interest in athletic affairs at Illinois. He has long been an intimate associate of Coach Zuppke.

President Howson will represent the Board of Direction and bring a message from the Society to the Young Men's Forum.

There will be instrumental and vocal music and other entertainment features interspersed throughout the program. The dinner starts at 6:30 P. M. and the price of tickets is $2.00 each. The tickets may be secured at the society office or from members of the Executive Committee of the Forum.

Difficult Foundation Work on White River Bridge

When the piers supporting an important bridge on the main line of a trans-continental railway begin to move and settle, the bridge engineers have something to worry about to keep the lines open to traffic. This is the situation which confronted the Bridge Department of the C. R. I. & P. Ry. when their bridge over the White River in Arkansas began to fail.

A. S. Armstrong, Superintendent of Construction, Bates & Rogers Construction Co. of Chicago read a paper before the Society, March 30 in which he described the construction of the new bridge at this location. The old bridge was built in 1870 being a combination of timber and iron Howe truss span construction. In the successive changes of ownership of this part of the line since that time, the records of the original bridge were lost so that nothing was definitely known as to the depth or style of foundation. Consequently it was decided to remove the old piers and put in new ones. The present steel bridge was supported on false work so constructed as to span each of the old piers and give space to permit construction of coffer dams for the new work.

Considerable trouble was encountered in taking out the old foundations which were from 8 ft. to 45 ft. below water level. Because of the semi-annual floods the work was interrupted several times. Mr. Armstrong described each of the operations in detail, illustrating his address with numerous photographs.

This is a piece of work which must have been very interesting to the men who were on it, although the story was told in a matter-of-fact way, just as if there was nothing unusual about it. The bridge consisted of 3 spans of 150 ft. and 1 vertical lift span 187 ft. in length. I. L. Simmons, Bridge Engineer of the Rock Island Railroad, contributed some interesting description of the work.

The Red Cross in Relief

Experiences of the American Red Cross in relieving the suffering in the tornado swept area of Southern Illinois were described at the Noonday Luncheon April 3, by Dr. H. W. Gentles, M.D.C.M. Director of First Aid, Chicago Chapter, American Red Cross.

Dr. Gentles arrived in the storm area about 12 hours after the storm struck. He described many of the scenes that he saw without going into detail of the agony and suffering. Many of the freaks of this storm have been described in the newspaper stories that we have read and according to Dr. Gentles they were not exaggerated in the least. There is always an inclination to doubt the stories of such disasters but he said that after his experience he was ready to believe almost any of them.

The Red Cross is the agency through which relief work is being centralized. It is now serving 2,000 meals per day and will continue to do so until the sufferers are able to take care of themselves. At every point where relief stations were established, use was made of large rooms, such as lodge halls, churches, etc., which were filled with cots so that the injured could be taken care of. It was noticeable in this storm that most of the people injured were hurt either in the back or about the face. This is accounted for by the fact that persons naturally turned their backs to high wind and in looking around to prepare to dodge flying objects get hurt in the face. All of the injurics were caused by flying sticks and splinters which were driven at tremendous velocity. There are many cases of pieces of shingles being driven through a board and in one place a stick was driven through a twelve-inch poplar tree.

The most notable thing about the whole district is the extreme quiet as no one wants to talk but is satisfied to be alive and very appreciative of the help so generously given.

Dr. Gentles was primarily interested in the hospitals which he described telling how each one is trying to take care of the load thrust upon it.

The Red Cross has organized its work systematically so that it is able to supply almost any need immediately. It has demonstrated in this storm as in many previous cases that the best work in first relief is done by a small highly trained force, rather than a great outpouring of unorganized assistance. He described the organization which the Red Cross is able to put in the field in Chicago inside of an hour. This is made up of men trained in first aid work in factories and utilities who can be mobilized quickly.

Carrier Current Telephony

Telephoning over high voltage power transmission lines sounds like it would be an easy thing for an engineer to work out but in fact it is the opposite. N. H. Slaughter, Engineer, Bell Laboratories, Inc., New York, read a paper before the Society April 6 on the subject, in which he described some of the intricate problems that are encountered.

There are many objections to using the towers for carrying telephone wires which are one of the essential parts of any power transmission system. Because of the dangers introduced many companies have gone to the expense of building entirely separate telephone lines, or leasing wires from telephone companies, either of which is sure to require a rather heavy capital and operating expenditure. If some means could be contrived for using the power transmission wires to carry the telephone circuits, considerable expense could be saved. Difficulty lies principally in making a safe connection to the power lines.

The Bell Laboratories, formerly known as the Research Department of American Telephone & Telegraph Co., has been at work on this problem for a long time and has developed a system which operates satisfactorily but still is open to some improvement. Briefly the system used is what is known as the Carrier Current Method, that is to say, carrier current of high frequency is superposed upon the power circuit, and transmitted over the line. At the receiving station the high frequency current is transmitted to the telephone system by an apparatus which will not permit the low-frequency power currents to pass. There it is amplified by vacuum tube amplifiers and the modulation becomes intelligible as speech in the telephone receiver.

The principal difficulty encountered has been to secure a safe means for connecting the telephone circuit to the power circuit which may be as high as 220,000 volts. Mrs. Slaughter described the devices which have been used to accomplish this connection by means of coupling wires or fixed condensers. Once this connection is established the next problem is to develope methods of making the system work both ways, so that two way transmission can be secured. This is accomplished by sensitive filters which permit the stations to send at different frequencies.

Mr. Slaughter showed a number of lantern slides giving wiring diagrams and descriptions of the apparatus which has been put into successful use in several large systems. One question remains to be solved, namely, that of finding a means for transmitting the telephone circuit around the break caused by opening up sectionalizing switches to permit repairs on the transmission lines.

State Sanitary Engineer Tells of Tornado

Harry F. Ferguson, chief sanitary engineer of the State Department of Health presented "an engineer's story of the tornado" before the Young Men's Forum on Wednesday evening, April 8. Mr. Ferguson stated that he did not pose as an expert on tornadoes but would give some general observations made by one who knew little or nothing about tornadoes before this one occurred in southern Illinois recently.

Early news of the destruction reached division headquarters of the Illinois Central Railroad through its station agent. They immediately arranged to send a relief train into the stricken area and so informed the Governor in Springfield. The State Departments interested, including public health, made arrangements to use this train. Mr. Ferguson was in Chicago at the time but arrived in the area early the next day, taking

charge of the sanitary engineers who had gone down on the relief trains.

Mr. Root, head of the Springfield office of the weather bureau, has said that this tornado, though the most destructive on record, was not as long as the Mattoon tornado of 1917.

The recent one was nearly two-hundred miles long, cutting a path a mile wide and skipping nothing. The lateral velocity has been carefully determined from data taken from electrically operated clocks and train dispatchers records of wires that were stopped when the storm snapped them in passing. This velocity was sixty miles per hour while the velocity of twist has been variously estimated at from one hundred to two hundred miles per hour.

Many people were led to believe that the wind had a clockwise rotation because of the positions in which various objects were left. Mr. Root states that this was not the case, however, as this tornado, in common with others in this hemisphere, had a counter clockwise rotation. Those occurring in the southern hemisphere invariably have a clockwise rotation.

As indicative of the way one's remarks may be intercepted, Mr. Root mentioned to a newspaper man that he had noted a stucco house standing while its neighbors were completely destroyed. Subsequently he was widely quoted through the press as saying that stucco houses stood up best. Now he is flooded with letters from commercial stucco people asking for testimonials and articles recommending stucco construction.

Opening with these general remarks, Mr. Ferguson then told of the sanitary conditions existing in these towns and the work of the sanitary engineers in protecting health after the storm.

Only two of the five towns affected had public water supply, the others depending on individual wells and cisterns. West Frankfort pumped the turbid river water to town without clarifying or treating it; the supply of drinking water being obtained from the local ice plant or from wells. An emergency chlorinator was installed to treat all the water pumped by the municipal plant. This was necessitated by the likelihood of the city water being used for drinking purposes, as the ice plant was destroyed and many of the private wells demolished. This chlorinator has made the water much safer than ever before, and its use will be continued.

Many wells were demolished and filled up with debris. Others were cleared and treated and so marked by placards. The many animals killed by the storm proved a considerable problem to the engineers as the carcasses had to be disposed of before they became a source of grave annoyance. Volunteer labor and the plentiful supply of old wood soon cleared this hazard by incineration on the spot.

The Murphysboro water supply was not damaged by the storm and as soon as the electric supply was reestablished this was put into operation. The water was taken from the river, filtered and sterilized by dosage. When the fire broke out the operator by-passed the filter because of the excessive demand for water. The sanitary authorities re-established the filtering and tripled the dosage, for a time, correcting any untreated water that might have been in the pipes.

Three tent camps established by the military department and tents pitched on old home sites have added to the problem of sanitary supervision as they will probably continue to be used until late in the fall.

The storm has resulted in a civic demand for a pure and properly protected public water supply, garbage collection and disposal, mosquito eradication and supervision on the part of the district sanitary engineer. This will result in an area better policed and safe-guarded as to sanitary details than existed there before.

Mr. Ferguson showed many slides of freaks and destruction caused by the storm.

Victor Guillemin, M. W. S. E. who for a number of years has been connected with the Wisconsin Bridge & Iron Company of North Milwaukee, Wis. writes that he expects to be abroad for the remainder of the year.

Inspect Niles Center Extension

A special train took the members of the Western Society of Engineers over the recently completed Niles Center Extension of the Chicago Rapid Transit Company on their excursion April 11. About 125 members and guests made the trip.

This five-mile extension was constructed in a period of about 10 months, in spite of a number of obstacles that had to be overcome. Some of the heaviest concrete work was completed during the coldest part of the winter. Another factor which has caused some trouble is the loose sand which was encountered in excavating the cut at the east end of the extension.

Engineers from the Chicago Rapid Transit Lines accompanied the train which made stops at all the principal points where anything of interest was to be seen.

The first stop was at the subway under the Chicago & Northwestern Ry. and Evanston Street Railway Tracks. The first of these is of heavy reinforced concrete construction. The other is of steel carrying the regulation paved street with car tracks. This is the lowest point in the cut and there is considerable seepage water to be removed. The sides of the cut had to be protected for almost a mile by cribbing backed up by cinders. An automatic pump forces the drainage water over the highest point in the system whence it drains into the canal.

Several of the stations were inspected and a stop was made alongside the new North Shore Treatment Works of the Sanitary District of Chicago which are now in process of construction. From this point it was possible to secure a birds-eye view of the work in progress, which will cost about thirteen million dollars when completed.

At the end of the line, the party went into the new automatic sub-station which supplies power for operating the trains. This station is designed to operate without supervision, except by remote control from the load dispatcher's office in the Edison Bldg. When the demand for power at this point exceeds a predetermined figure for a predetermined length of time the station will automatically start up and furnish power as long as the demand exists. It will protect itself from electrical disturbances, such as short circuit, ground, overload and hot bearings.

On the return trip a stop was made to inspect the 1000-ft. steel bridge which spans the canal, the C. & N. W. Tracks and the proposed McCormick Highway. The elevation at this point is 38 ft. above the natural ground level.

The overhead distribution system attracted some attention. The trolley is supported by double catenary, carried on fabricated steel towers and overhead bridges. The distribution system is designed especially for high speed trains, which will ultimately be operated over this section of the line, when it becomes a link in the new high speed cut-off through the Skokie Valley to Waukegan.

Handling Material at Hawthorne

Material Handling is a large subject and particularly when it concerns such quantities as encountered at the Hawthorne Works of the Western Electric Co. where one-eighth of the lead produced in the United States is consumed. This was the subject of the paper read before our meeting April 13 by F. J. Feely, Engineer, Development Department, Western Electric Co. Perhaps it is not generally known that the average number of cars switched for this plant during 1924 was 110 per day, requiring three steam locomotives to maintain the service.

Mr. Feely dealt particularly with the handling of the raw material, as he stated that it would be impossible to describe all the operations throughout such a plant which manufactures over 100,000 standard piece parts besides an enormous number of special parts which are not standardized. He first analyzed the condition which lead to their choice of storage battery locomotives for switching cars. They have several locomotive cranes which are used for a variety of duties. Their new plant in Kearny, N. J. will have one of the first storage battery locomotive cranes ever

built. There are certain classes of material and certain kinds of transportation where auto trucks can be used to advantage, as for example transporting finished telephone apparatus to the warehouse, where it is packed, stored and shipped and transportation of some materials in process from one building to another. Coming to the handling of materials in the rod and wire mill, Mr. Feely described the mono-rail system which has been installed. By the use of this system it was possible to reduce the width of the building 21 ft. since it was not necessary to provide for a trucking aisle. Monorails cover all parts of the storage area, pickling tanks and rod mill. The car runs on to a transfer bridge which then becomes a crane. Copper wire is handled by various means at different points in its progress.

The ten carloads of lead per day arriving at the plant constitute one of the most difficult material handling problems. The lead is received in box cars and after it is once taken out of the car and placed on skids, it is comparatively easy to handle by ordinary cranes. Handling the enormous reels of lead covered cable has been simplified by the development of some special trailers, having a lifting mechanism operated by the motor on the tractors.

Over one hundred sizes and grades of lumber are carried on hand, all of which have to be handled into the storage yard and then into the dry kiln and out again before being sent into the shop for manufacture. A storage battery electric locomotive is used exclusively for shifting cars of lumber in lumber yards. Over 20 million board feet of soft wood lumber was used in 1924 for the manufacturing packing boxes and cable reels. This gives some idea of the quantities handled.

Special attention was given to handling acid, silica sand, tools and dies.

This was a joint meeting with the Chicago Section, American Society of Mechanical Engineers and was attended by an appreciative audience.

W. W. DeBerard, M. W. S. E. was elected trustee of the Village of Wilmette at the election held early in April. There are now three engineers on the Board of Trustees of Wilmette.

Interesting Things Seen at Baking Institute

Again the Young Men's Forum has found an interesting place to inspect for its monthly excursions. This time it was the American Institute of Baking at 1125 Fullerton Ave., which was visited on the evening of Thursday, April 16th.

The Institute is a combination school, research laboratory and model bake shop. A special session was arranged in the evening so that a larger attendance could be secured and the members were invited to bring the ladies who were particularly interested in this subject. Dr. Morrison and his associates explained the work of the different departments to the whole party in one of the large class rooms. Separate groups were then conducted through the Institute by other members of the staff who explained everything as they went along.

The Institute is well equipped with chemical and bacteriological laboratories for instruction and research work. The model bake shop is equipped with everything found in a commercial bakery, except on a somewhat smaller scale. Bread and rolls are baked every day by the students and then analyzed and graded. The results of the research at the Institute are made available to members of the American Bakers Association.

A point of particular interest was the nutrition laboratory which is fitted up to study the food values of different kinds of bread. Here they have about 200 cages of white rats which are fed on different kinds of bread and the effect of this ration on their physical condition carefully noted. Some of them become paralyzed, others go blind while others grow to unusual size. By observing these effects the Institute is able to determine accurately the nutritive value of bread baked under different conditions and by different formulas. The Institute takes particular pride in its library which is said to be the finest in America on fermentation subjects. It also has an excellent collection of yeasts of all kinds.

Reports on Free Engineering

Several months ago the Board of Direction appointed a special committee as reported in the October, 1924 Journal to make a study and report on a number of statements that have been received by the Society, relative to the practice of offering free engineering services, in connection with the sale of equipment. This committee consisted of the following:

H. J. Burt, Chairman
C. B. Burdick
W. J. Lynch
Linn White
R. G. Rosenbach
V. A. Matteson
J. T. Hanley

After a rather exhaustive study of the subject in conjunction with representatives of the Chicago Chapter, American Institute of Architects and the Illinois Society of Architects, the Committee has returned its report to the Board. The report will be released as soon as it has been approved by the two organizations just mentioned. The statements on which the report is based claim that injustice has been done to professional engineers and the public.

Rules of the Washington Award Changed

The Washington Award Commission in considering candidates for the Award for 1924, have found that certain changes in the rules were desirable.

Under the rules of the Award the names of candidates eligible to receive it must be before the commission for a period of one year. These names are carried forward from one year to the next and under the previous plan there was no means of removing them from the eligible list, after it had been clearly shown that they were outranked by other individuals. The present Commission has recommended and the Board of Direction has approved new rules which permit the commission to remove names from the eligible list after a period of years. This will keep the list of eligible candidates within workable limits.

Candidates for the Washington Award are not advised that their names are being considered. The names can only be placed on the eligible list by others. The Washington Award Commission is anxious to have before it for consideration the names of all engineers who are worthy of consideration for the Award. These men will not submit their own names for consideration so their friends must do it for them. The commission therefore requests that members of the Society suggest to the Secretary, the names of men whom they consider worthy of receiving the Washington Award, together with a statement of their reasons for making such suggestion. A name must remain on the eligible list for at least one year, before it can be voted upon for the Award.

Condemns Child Labor Amendment

After having been deferred because of the press of important business before the Board of Direction, the resolution of the Public Affairs Committee condemning the proposed Twentieth Amendment to the Constitution known as the Child Labor Amendment was passed April 20th. In arriving at its conclusions the Public Affairs Committee devoted two sessions to the discussion of this amendment and finally submitted it to a letter ballot of the entire committee. It was thereupon referred to the Board of Direction by the following resolution which had the approval of the Public Affairs Committee.

RESOLUTION

WHEREAS, there is before the country a proposed amendment to the federal constitution which has been ratified by one state and which has been rejected by five states, and which reads as follows:

Section 1. The Congress shall have power to limit, regulate and prohibit the labor of persons under eighteen years of age.

Section 2. The power of the several states is unimpared by this article except that the operation of state laws shall be suspended to the extent necessary to give effect to legislation except by the Congress.

and

WHEREAS, the states themselves have ample power to regulate child labor and, in fact, are actually regulating child labor to the extent that public sentiment within the states will support legislation, and

WHEREAS, the principal beneficiaries of uniform child labor laws throughout the United States, namely, the industries, are generally unfavorable to the amendment, and

WHEREAS, the proposed amendment tends toward a modification of the established form of our government.

THEREFORE, BE IT RESOLVED, that the Western Society of Engineers is opposed to the adoption of the proposed twentieth amendment, but wishes to go clearly on record as being in favor of intelligent child employment legislation in the several states, and also in favor of securing uniformity in such legislation in so far as this can be accomplished through cooperation among the several states.

As passed the resolution recommended that copies be sent to each member of the legislatures of Illinois, Wisconsin, Michigan, Indiana and Iowa. Since the passage of this resolution each of these states has rejected the amendment.

Engineers Double Their Quota

In the recent campaign for relief funds for the sufferers from the tornado in southern Illinois, conducted under the direction of the Association of Commerce, the engineers subscribed more than twice the amount allotted to their division.

The following is the report of Frank D. Chase, M. W. S. E., Chairman, of the committee for the engineers division.

"Division No. 19, Engineers, Chicago Association of Commerce, were called upon for $2500.00 for the Tornado Relief Fund.

"Your Chairman takes pleasure in advising that this quota was exceeded and that the total amount raised was $5262.58. Of this $2354.40 was sent direct to the Association by members of the Division and others and credited to the Division's quota.

"In addition to the appeal which secured this amount from the members of the Association, part of which was secured by personal request from your Chairman to the members of the Division, we sent out a letter with return envelope which netted $2908.18. This went to the mailing lists of the Engineering Societies of Chicago. A total of 4257 letters was sent out and 467 replies received, 71 of which comprised only a statement that contribution had been made through other channels.

"Through the energetic action of Mr. J. W. Lowell of the Universal Portland Cement Company, these letters were all printed and mailed by him and his organization before ten o'clock on Monday morning after the meeting of the Committee at eleven o'clock on the preceding Saturday. This rapid work on Mr. Lowell's part permitted us to get the appeal before the Engineers promptly.

"The cost of printing and mailing, approximately $100.00, was borne by the Universal Portland Cement Company, through the courtesy of Mr. Blaine S. Smith, General Manager of the Universal Portland Cement Company.

"I hope that the above meets with the approval of the Committee."

Yours very truly,
FRANK D. CHASE, Chairman

Help Wanted

Does any member know the present address of any of the following who have moved without advising us of their new location.

C. Lee Primrose, 729 Washington Blvd., Chicago, Ill.

Bernardino Guerrero, 801 N. La Salle St., Chicago, Ill.

Wm. J. Wells, 1259 N. Dearborn St., Chicago, Ill.

Henry J. Fox, 1310 McKinney Ave., Houston, Texas.

Robert Schlemm, 4235 Cottage Grove Ave., Chicago, Ill.

Frederick C. French, Durant Motor Co., Elizabeth, N. J.

Mail is being returned to us from each of these addresses and other channels of communication have failed to reach them. Any assistance will be much appreciated.

Amendments to Constitution Adopted

Two amendments to the Constitution of the Society were reported to the Board of Direction at its meeting April 20, after having been submitted to the membership for letter ballot. These amendments are in relation to the limitation of Junior and Student membership. The changes make the period of limitation correspond to the Society's fiscal year, rather than the calendar year.

As amended Article III, Sect. 5 now reads:

"A Junior Member shall have been engaged in the practice of his profession for not less than two years and shall be a person who is not eligible for Corporate Membership. His connection with the Society shall terminate with the fiscal year in which he becomes twenty-eight years of age, unless he shall have previously been transferred to another grade, excepting that additional time not exceeding three years may be allowed a Junior Member at the discretion of the Board of Direction should he fail to qualify for transfer to another grade."

As amended Article III, Sect. 7 now reads:

"A Student Member shall, at the time of his admission be an under-graduate in the Junior or Senior year in a technical school of recognized standing. His connection with the Society shall terminate with the fiscal year following the one in which he becomes eligible for Junior Membership, but shall terminate at the end of the third fiscal year after his admission, unless previously transferred to another grade."

By-Laws Amended

Our Development Committee has been making a study of some of the details of the organization of the Society during the past winter and as a result has recommended certain amendments to Article IV of the By-Laws.

Briefly stated these amendments provide that the Executive Committee of each section shall select the Chairman, Vice Chairman, member of the Program Committee and member of the Publication Committee from its own membership. Under the new plan the Executive Committee shall consist of six directors, serving three year terms, two of which are to be elected each year. It is hoped that the new method of choosing officers and committee members will result in more thought being given to it than has been customary in the past.

These amendments were referred to our Board of Direction in the manner prescribed by the Constitution and were approved by the Board at its April meeting. Inasmuch as the selection of officers for the Sections has been completed for the coming year, the amendments will become effective June 1, 1925.

The Constitution provides that the chairman of each section is a member of the Board of Direction.

A. C. C. to Meet

The Spring Meeting of the American Construction Council will be held at the Hotel Biltmore, New York City, on May 8 and 9, 1925. Following is the general program:

1. Friday, May 8th, 10 A. M.—Meeting of the Board of Governors and others interested. At this meeting general conditions effecting the construction industry nationally will be considered and the Council's usual statement to the public formulated, followed by a business session of the Board at which the Council's various activities will be given special consideration.
2. Friday, May 8th, 2 P. M.—Conference on Better Building with special reference to ways and means of furthering the building of better homes and securing proper housing financing. At this meeting the Council's Committee on Better Building will make its report.
3. Saturday, May 9th, 10 A. M.—National Conference on Elimination of Construction Peaks and Depressions. The causes of seasonal inactivity have been extensively analyzed and certain remedies suggested. The purpose of this conference is to assist in bringing about that coordination within the industry and its related groups necessary to secure the desired corrections.

A Story With a Purpose

I was informed by a friend that the above is not correct. That the story is only a record and the purpose is in the mind of the individual. When the individual reveals his own purpose in public addresses and papers and combines them (in order) in book form, it seems to me that it may be called a Story with a Purpose.

Mr. Samuel Insull is called upon to make many addresses. They are always well received. They present a constructive analysis of economic problems and reveal a definite purpose.

In 1914 Mr. Insull privately issued a volume entitled "Central Station Electric Service," containing his public addresses prior to that date. "Public Utilities in Modern Life", is now privately issued and contains the more recent addresses. It is a pleasure to acknowledge the thoughtfulness of the author in presenting these books to the Library of the Western Society.

Engineers are often involved in the technical problems of Engineering to such an extent that the purpose of the enterprise is overlooked or assumed. I believe that true engineering as a contribution to human progress is more than these technical details. Is the enterprise economically sound? How can the engineer contribute most? These should be the most important considerations and will return to the engineer the greatest compensation, the satisfaction of constructive effort.

I would commend Mr. Insull's books to all our members. They are as fascinating as a novel. They contain action and accomplishment, analysis and conclusion; conception and plan.

The introduction is by Mr. Wm. E. Keily, M. W. S. E.

EDGAR S. NETHERCUT
Secretary

J. A. Scanlan, M. W. S. E., Structural Engineer formerly with the Victor C. Carlson Co. of Evanston, has acquired an interest in the Blanchard Construction Co. The new offices of that company are located at 825 Chicago Ave., Evanston, Ill. The company engages in general building construction.

Book Notices

510
S823e3
Engineering mathematics
By C. P. Steinmetz. 3d ed. rev. and enl. N. Y. McGraw, 1917. 321 p. Tables, diagrs.
Treats in detail, with numerous practical examples, all the branches of mathematics which are of special importance to the electrical engineer.

CHEMICAL MATERIAL

540.3
K55c3
Chemical encycloedia.
By C. T. Kingzett. 3d ed. N. Y. Van Nostrand, 1924. 606 p.
A digest of chemistry and the chemical industry in an alphabetical arrangement, consequently easily used for reference purposes. This edition is carefully cross indexed. The information about each item is brief and concise, usually consisting of physical data, chemical constituency, and use.

660
L712h
Handbook of chemical engineering.
Edited by D. M. Liddell. 2v. N. Y. McGraw, 1922. Illus., tables, diagrs.
A description by leading chemical engineers of the U. S. of the features essential to all of the chemical industries of the country. Basic principles are emphasized, and each section usually ends with a number of specific industrial applications, preferably in varied lines. A general knowledge of chemistry and mathematics is presupposed.

541.06
A512
American Electrochemical Society Transactions.
N. Y., A. E. S., 1921-1924. v. 39-45.
Authoritative papers on a subject of increasing interest.

622.009
C212a
Development of chemical, metallurgical, and allied industries in Canada in relation to the mineral industry.
By A. W. G. Wilson. Ottawa Govt., 1924. 329 . Diagrs. (Canada. Dept. of Mines. Mines Branch. Pub. 597.)
A review of Canadian industries, statistical and official.

F523
Report on the fire hazard of ethane, propane, butane and ammonia as refrigerants.
B. A. H. Nuckolls. Chicago, Underwriters' Laboratories, 1925. 95 p. Illus., tables, diagrs.
A pamphlet which should be in the hands of every refrigerating engineer. Gives methods of tests, results of tests and conclusions with regard to general fire hazard, fire hazard as refrigerants. Suggests measures of protection for industrial systems using these materials.

METALLURGY

669.1
H255m7
Metallurgy of steel.
By F. W. Harbord and J. W. Hall. 7th

ed. thoroughly rev. London Griffin, 1923. v. 1 Metallurgy. v. 2 Mechanical treatment. (Griffin's metallurgical series).

An authoritative, detailed discussion, amply illustrated, of the manufacture of steel. Volume one deals with the chemical processes involved; volume two with the mill routine to the finished product.

669.1
F974h

Heat treating; its principles and applications.

By C. H. Fulton and others. Cleveland, Penton, 1924. 93 . Illus., tables, diagrs.

After a general discussion of the physical properties and structure of iron and steel, this book contains five chapters devoted to the processes of heat treating; annealing, hardening and tempering, carburizing and case hardening. The last chapter deals with the electric furnace.

621.434
M879d

MECHANICAL ENGINEERING

Diesel engines.

By L. H. Morrison. N. Y. McGraw, 1923. 598 p. Illus., diagrs.

A practical treatment of the construction, operation and economics of Diesel engines. Special attention is given to cooling systems, fuels and lubrication, installation and testing, indicators, and production costs.

621.13
G865

Locomotive catechism.

By Robert Grimshaw. N. Y. Henley, 1923. Illus., diagrs.

A complete work on the design, construction, running and repair of all kinds of locomotives. The book is in the form of questions and answers arranged under general subjects, but a detailed index is provided for ready reference.

536
C941

Practical heat.

By Terrell Croft. N. Y. McGraw, 1923. 713 p. Illus., tables, diagrs. (Power plant series.)

The object of this book is to present the theoretical principles and the practical applications of heat in a manner which may be intelligently followed by persons of a limited mathematical knowledge. A treatment of the fundamental concepts of force, pressure, power, etc., is followed by divisions on the laws of thermodynamics, the effects of heat, the various applications of heat phenomena, and on the instruments used in heat engineering.

629.1
A939s

Specifications on automotive electrical equipment and recommended practices as to installation and wiring.

By the Automotive Electric Association. Cleveland, A. E. S., 1925. 23 p. Diagrs. Loose leaf form.

Authoritative standards on a phase of the automobile and electrical industries which is not stressed in current literature.

Additions to the Library

American Concrete Institue. Proceedings. 1923.

Boston. Dept. of Public Works. Annual report. 1923.

Clarke, F. W. Composition of the river and lake waters of the U. S. (U. S. Geol. Sur. Prof. Pap. 135.)

Illinois State Water Survey. Bulletin 20. Comparison of chemical and bacteriological examinations made on the Illinois River during a season of low and a season of high water, 1923-1924.

Jakosky, J. J. The electrical manufacture of carbon black. (U. S. Bur. of Mines. Tech. Pap. 351.)

Kirk, R. E. Manufacture of Portland Cement from marl. (Minnesota Univ. Eng. Exper. Stat. Bulletin 2.)

Bowley, F. B. Transmission of heat through building materials. (Minnesota Univ. Eng. Exp. Sta. Bulletin 3.)

Society of Industrial Engineers. Report of proceedings 11th national convention 1924. Title: Reducing the cost of business.

U. S. Dept. of Public Health. Special report relative to the matter of sewerage disposal in the valley of the Merrimack River. 1924. Contains plans for a trunk sewer system with alternative systems for the cities of Lowell, Lawrence, Haverhill and 14 others.

Virginia Geological Survey. Bulletin 25. 1925. The Valley Coal fields of Virginia, by M. R. Campbell and others; with a chapter on the Forests of the Valley Coal fields of Virginia, by F. C. Pederson.

Gifts to the Library

The recent report of the American Engineering Council on Industrial Coal: Its purchase, delivery and storage, was given to the Library by Mr. Nethercut. Mr. Nethercut also gave us an early book on surveying by Frederick W. Simms called " A treatise on the principles and practice of levelling," which was published in Baltimore in 1837.

Mr. Robert Forsyth, who has been keeping our set of the publications of the Iron and Steel Institute up-to-date, sent us volumes 109-110 of the Journal

and volume 13 of the Carnegie Scholarship Memoirs.

The 1922 and 1923 volumes of the Brown Boveri Review, which were presented to us by Mr. G. W. Swallow, complete our file of the English edition of this excellent house organ.

Mr. J. G. Jordan gave us his copy of the Radio News for May, 1924 to take the place of the one which disappeared from the library rack.

STRUCTURAL MATERIAL FROM THE LOTHHOLTZ COLLECTION

General

Ellis, C. A., Essentials in the theory of framed structures. 1922.

Godfrey, Edward. Steel designing. 1913.

Hess, H. I. Graphics and structural design. 2d ed. 1915.

Hool, G. A. and Kinne, W. S. Structural members and connections. 1923.

Merriman, Mansfield and Jacoby, H. S. Stresses in simple trusses. 6th ed. 1905.

Morley, Arthur. Theory of structures. 1912.

Pennsylvania Steel Co. Report on the Blackwell's Island bridge. 1909.

Rings, Frederick. Reinforced concrete bridges. 1913.

Skinner, F. W. Specifications and standards for short railroad spans. 1908.

Foundations

Hool, G. A. and Kinne, W. S. Foundations, abutments, and footings. 1923.

Stresses

Cain, William Maximum stresses in framed bridges. 1897.

DuBois, A. J. Stresses in framed structures. 10th ed. 1896.

Heller, A. H. Stresses in structures. Rev. by C. T. Morris. 3d ed. 1916.

Howe, M. A. Influence diagrams for the determination of maximum moments in trusses and beams. 1914.

Smith, Albert. Stresses in simple framed structures. 1911.

Arches

Cain, William. Theory of steel-concrete arches and of vaulted structures. 5th ed. 1909.

Tyrrell, H. G. Concrete bridges and culverts. 1909.

Roofs

Inskip, G. R. Treatise on mathematical and graphical roof framing. 1900.

McKibben, H. L. and Gray, L. E. Hip and valley design; details, formulae and graphics; roofs, hoppers and pipe line. 1912.

MATHEMATICS FROM LOTHHOLZ COLLECTION

General

Capito, C. A. A. Text-book of mathematics and mechanics. 1913.

Mann, H. L. Text-book on practical mathematics for advanced technical students. 1915.

Rose, W. N. Mathematics for engineers. v. 2. 1920.

Saxelby, F. M. A course in practical mathematics. 1913.

Seaver, E. P. Mathematical handbook, 1907.

Slichter, C. S. Elementary mathematical analysis. 2d ed. rev. 1918.

Sprague, E. H. Elementary mathematics for engineers. 1916.

Webber, W. P. and Plant, L. C. Introductory mathematical analysis. 1919.

Tables

Bremiker's tables of the common logarithms of numbers and trigonometrical functions to six places of decimals. 10th ed.

Chappel, Edwin. Five figure mathematical tables. 1915.

Pocket logarithms to four places of decimals. 1883.

Vega, George, freiherr von. Logarithmic tables of number and trigonometrical functions. Trans. by W. L. F. Fischer. 1856.

Trigonometry

Palmer, C. I. and Leigh, C. W. Plane and spherical trigonometry. 2d ed. 1916.

Descriptive Geometry

Follons, G. H. Essentials of descriptive geometry. 1908.

MacCord, C. W. Elements of descriptive geometry with applications to isometrical drawing and cavalier projection. 2d ed. rev. 1902.

Smith, W. G. Practical descriptive geometry. 2d ed. rev. 1916.

Analytic Geometry

Siceloff, Wentworth and Smith. Analytic geometry. 1922.

W. G. Arm, M.W.S.E., Asst. Chief Engineer, Chicago Terminal Improvement, Illinois Central R. R. Co., has been ill in the Illinois Central Hospital for about a month. He has gone to Gulfport, Mississippi, for a rest and is reported to be regaining his strength. He hopes to be back in Chicago about the first of May.

The Engineering Library of Northwestern University is very desirous of obtaining a copy of "Power", Vol. 49, No. 20, dated May 20, 1919, in order to complete the binding of their file of that publication. It is out of print so the publishers are unable to supply it but if any of our members happens to have a copy that he is willing to dispose of, it will be a great accomodation to the Library at Northwestern. If any one can supply this copy will he please communicate with the librarian of the Society, or with Prof. William H. Burger, M. W. S. E. at Northwestern University.

APPLICATIONS FOR MEMBERSHIP

Members of the Society can be of great service if they will make a practice of examining the list of applicants published herewith and promptly notifying the Membership Committee or the Secretary regarding the qualifications of any of those whose names appear on the list. The Society desires to extend its membership and receive those engineers who have the proper qualifications and wish to participate in its activities. The following applications have been received since last report:

No.	Name	Address
30—1925	J. Kenneth Mayer (Transfer)	Box 555, Belmar, N. J. .
31	Alva B. Simons	Northwestern University, Evanston, Ill.
32	George R. Culley	135 E. 11th Pl., Rm. 706, Chicago, Ill. .
33	Harry Kraft	151 W. Maple Ave., Downers Grove, Ill.
34	Edward J. Jaros	1244 N. Central Ave., Chicago, Ill.
35	Andrew F. Marsch	12127 Eggleston Ave., Chicago, Ill.
36	Frank J. Kornacker	2000 Addison St., Chicago, Ill.
37	M. M. Newlander (Transfer)	123 Pratt Block, Kalamazoo, Mich.
38	James E. Mackay	224 E. Huron St., Chicago, Ill.
39	Robert E. Hattis	4152 N. Mozart St., Chicago, Ill.
40	John Lazdauskis	6044 S. Peoria St., Chicago, Ill.
41	R. Roy Dunn	c/o Y. M. C. A., Gary, Ind.
42	Harry C. Peterson	1915 Balmoral Ave., Chicago, Ill.
43	Fred Farrell	2420 Noyes St., Evanston, Ill.
44	Carl F. Lorimer	628 Eauclair Ave., Columbus, Ohio
45	F. Raymond Nelle (Transfer)	3222 Michigan Ave., Chicago, Ill.
46	Arthur G. Dixon	5518 W. Ohio St., Chicago, Ill.
47	Guy R. Buck	2322 Argyle St., Chicago, Ill.
48	Chas. A. Nagel	Downers Grove, Ill.
49	Mortimer J. Frankel	1512 Hyde Park Blvd., Chicago
50	Henry Irwin	6807 Indiana Ave., Chicago, Ill.
51	Edward J. Hughes	810 Otis Bldg., Chicago, Ill.
52	Charles S. Riche	c/o Victor J. Miller, Boatmen's Bank Bldg., St. Louis, Mo.
53	George W. Lyons	1400 E. 53rd St., Rm. 430, Chicago, Ill.
54	Bahig Hassan	1410 Wrightwood Ave., Chicago, Ill.
55	Fred K. North	Ill. Malleable Iron Co., 1801 Diversey Parkway, Chicago, Ill.
56	Paul A. Nemoede	2734 N. Sacramento Ave., Chicago, Ill.
57	James E. Farnsworth	3902 N. Kenneth Ave., Chicago, Ill.
58	A. R. Lepin	508 So. Lawndale Ave., Chicago, Ill.
59	Mariano Morano	Bridge Dept., C. R. I. & P. Ry., La Salle St. Sta., Chicago, Ill.
60	Allen W. Stephens	6 N. Michigan Ave., Chicago, Ill.
61	Marx, Lester M. (Transfer)	1535 E. 61st St.

Samuel R. Lewis, M. W. S. E. and Edmund F. Capron announce that in mutual and friendly agreement they have decided to discontinue the business of Lewis & Capron Co.

Mr. Lewis continues in the engineering profession under his own name at 1155 Old Colony Building, 407 South Dearborn Street, Chicago.

An Early Report On Chicago Sewage

The question of the disposal of the sewage of Chicago is not a new one by any means, as is shown by an article printed in the *Engineering News Record* for April 16th, which is an abstract of a report by E. S. Chesbrough, City Engineer of Chicago. This was taken from a report made in 1855 which was reprinted in the Engineering News in April 1875 at the time when Mr. Chesbrough was president of the Civil Engineers Club of the Northwest, which later became the Western Society of Engineers.

"Engineering Fifty Years Ago"

What Shall the Sewerage of the City Be Drained Into? Four principal plans, besides modifications, have been proposed:

(1) Into the river and branches directly, and thence into the Lake.
(2) Directly into the lake.
(3) Into artificial reservoirs, to be thence pumped up and used as manure.
(4) Into the river, and thence by the proposed steamboat canal into the Illinois River.

With regard to the fourth plan, or draining into the proposed steamboat canal, which would divert a large and constantly flowing stream, from Lake Michigan into the Illinois River, it is too remote a contingency to be relied upon for present purposes; besides, the cost of it, or any other similar channel in that direction, sufficient to drain off the sewage of the city, would be not only far more than the present sewerage law provides for, but more than would be necessary to construct sewers for five times the present population.

Should the proposed steamboat canal ever be made for commercial purposes, the plan now recommended would be about as well adapted to such a state of things as it is to the present, making it necessary to abandon only the proposed method of supplying the South Branch with fresh water from the Lake, and to pump up from the new canal, or draw from the Des Plaines directly, flushing water for the West District, instead of obtaining it from the present canal at Bridgeport as herein recommended.

NEW MEMBERS

The following were elected to membership in the grade shown by the Board of Direction, Mar. 16, 1925.

No.	Name	Address	Grade
521—1924	Maurice L. Vandervort	1617 Orrington Ave., Evanston, Ill.	Assoc.
557	Frank W. Leske	4953 Huron St., Chicago, Ill.	Associate
558	Magnus Gunderson	2844 Logan Blvd., Chicago, Ill.	Member
3—1925	Antonio J. Papa	204 S. College St., Angola, Ind.	Student
11	Howard Ford	207 E. South St., Angola, Ind.	Student
14	Allen L. Kukral	3247 S. Michigan Ave., Chicago	Student
15	Joseph Klecka	711 Diversey Parkway, Chicago	Student
16	William D. Shipman	Franklin Park, Ill.	Student
17	Warren J. Siegfried	3322 S. Michigan Ave., Chicago, Ill.	Student
18	E. W. Bell	4550 Lake Park Ave., Chicago	Affiliate
20	A. R. Kipp	123 W. Madison St., Chicago, Ill.	Member
21	Guy W. Correll	6018 Kenwood Ave., Chicago, Ill.	Student
22	A. J. Connelly	c/o Geo. Briggs, 58 W. Randolph St.	Junior
23	I. T. Landhy	1421 Norwood St., Chicago, Ill.	Assoc.
24	Jas. C. Trueman	5714 Blackstone Ave., Chicago, Ill.	Junior
25	Andrew Lebailly	1026 N. State St., Chicago, Ill.	Associate
26	Raymond J. Graham (Transfer)	c/o H. L. Stevens & Co. 30 N. Michigan Ave.	Member
27	John F. Little	5648 W. 65th St., Chicago, Ill.	Junior
28	E. C. Hach	1834 S. 48th Ct., Cicero, Ill.	Associate

Planning Chicago's Development

Report of the Committee In Charge of the Fourth Annual Convocation of the Western Society of Engineers

IN a great many respects the next ten years might be termed the Critical Period of Chicago's History. Emergencies exist at the present time, or will arise within that period, the proper meeting of which will determine largely whether Chicago will resume her forward march of progress which was partially interrupted by the Great War and seems to have been retarded further by a spirit of inferiority complex which has prevailed in later years.

Serious conditions confront the City of Chicago at the present time. Situations exist as to Local Transportation. Water Supply and Sewage Disposal, and Rail and Water Terminals which require early constructive action on the part of the people of this locality as a whole, as well as of their duly appointed governing authorities. Closely associatd with these more specific and concrete crises are the rather intangible but no less important conditions affecting the general subject of Public Welfare.

The foregoing and the elaboration of the principles which follow prove the need for general recognition of the common interests and common problems of the entire Chicago region comprising about 5,000 square miles. In replanning and rebuilding portions of the City of Chicago to take care of past shortcomings, the equal or greater need for avoiding similar mistakes in the rapidly growing sub-centers of the region should not be overlooked. Intensive studies of all the various phases of a comprehensive Chicago regional plan should be instituted at the earliest possible date.

Local Transportation

The following recommendations and conclusions emphasize the seriousness of the present situation with respect to local transportation and indicate the general principles which should control in its solution:

1. Consolidate and co-ordinate all surface and rapid transit lines so as to insure unified operation.
2. Studies of the street and highway situation now under way by the direction of the appropriate departments of the United States Department of Agriculture, the State Department of Public Works, the Cook County Highway Department, and the City of Chicago, should be completed as soon as practicable with a view to providing a plan for an adequate and co-ordinated system of highways for this area. As soon as the plan is finally adopted the financial and engineering work involved should be allocated and provided for, so that the highways needed can be constructed and put into service as rapidly as required.
3. With reference to the electric and steam railway suburban service, a commission should be appointed by all organizations concerned, including the carriers themselves, the city governments involved and the outstanding commercial and civic organizations in the area, to investigate the present and future requirements for suburban service and outline a program for the extensions and changes in operation which should be made to serve the growing population.

The importance of local passenger transportation to the life and development of a city can scarcely be overstated. It can be realized somewhat if it is imagined that beginning at midnight all the street cars, elevated and railroad trains, busses and automobiles in Chicago should be stopped. In such a situation the complete paralysis of the city's business and growth would quickly follow.

On the other hand constant improvement of local transportation facilities will stimulate the growth and development of a city as few, if any, other lines of improvement can. Therefore, any means within reason whereby trans-

portation can be improved should be given diligent consideration.

It is generally recognized by authorities that with Chicago's future added advantages as a seaport, her financial, commercial and industrial situation will be superior to that of any other city in the world, and that in keeping with that condition the population of her metropolitan area should also lead that of any other city.

The elements of Chicago's transportation situation most in need of present attention are the surface and elevated traction systems. These systems operated independently, are furnishing a service which, considering the legal and financial limitations under which they labor is high class. However, this service instead of being co-ordinated is competitive. Each system is now compelled to undertake a part of the work which logically belongs to the other, to its own loss and to the cost and delay of the citizens. The unified ownership and operation of these systems has been recommended by every competent report which has covered the situation during the past ten years.

Another means of transportation where the use and demand has outgrown the facilities provided is the automobile and bus traffic throughout the city and the metropolitan area. The street and highway system of the Chicago area has been developed in a more or less haphazard manner, by the various governmental bodies in authority, without providing for the through lines necessary to serve even the present vehicular traffic.

The metropolitan area of Chicago may be roughly considered as bounded by an arc with radius of 50 miles centered on the down-town district. It does not violently strain the imagination to see practically the whole of this area developed as residential, commercial and industrial districts.

Such a condition will require vastly increased facilities in the way of rapid electric and steam railway service throughout this area.

These sections which are now developed lie along the lines which furnish suburban service. This suburban service is now carried on by the steam railways with more or less interference with their through passenger and freight traffic.

A comprehensive study should be made of the future suburban traffic needs of this area, so that the whole population shall be adequately served, and all agencies coordinated so that there shall not be wasteful competition in certain localities, while others are not served.

Water Supply and Sewage Disposal

The basic principles underlying the solution of the crises relating to water supply and sewage disposal are as follows:

1. Universal metering of the city water supply should be adopted as rapidly as posible.
2. The present Lake Michigan water diversion should be permitted as a water supply protection measure until such time as the necessary sewage disposal plants are in operation.
3. The Sanitary District of Chicago should bend its energies toward the construction of sewage disposal works and should proceed just as rapidly as its financial ability will permit.
4. In view of the allied questions such as the development of water power, lake level control, and the Lakes to the Gulf Waterway, and the international importance of the Chicago sewage disposal problem, the interests of all concerned would be served by a conference preferably called by the President of the United States at which all interests should be represented.

A wholesome and abundant water supply is essential to the continued development of all important and growing cities. At the present time the Chicago Water Supply is deficient in quality and inadequate both as to quantity and pressure. These deficiencies result directly from an excessive wastage of water. The outstanding need of the Chicago Water Works is the elimniation of waste.

Savings of $200,000,000 can be affected in the next 30 years by an expenditure of but $13,000,000 for meters. Metering

will not only finance itself but will also pay for filtration of the entire supply and in addition yield a net revenue of $160,000,000 in the next 30 years as compared to the present wasteful methods of distribution. Elimination of waste is a necessary prerequisite to filtration. The usefulness of the present water works will be increased by elimination of water waste so that with but few additions it will be able to supply the needs of Chicago for thirty (30) years in the future.

Filtration is the primary line of defense against water borne disease. Filtration will eliminate the objectionable taste of the water due to the present necessity for heavy chlorine dosage, and will provide a clear sparkling water at all times. Waste elimination will enable the existing Water Works with filtration to furnish pure filtered water to the entire city, with adequate pressure and adequate in quantity, at costs less than at present paid for an inadequate supply of an inferior character.

Closely allied with the water supply problem is that of sewage disposal. Prior to twenty-five (25) years ago the major portion of Chicago's sewage emptied into Lake Michigan from which the water supply was taken. Typhoid and other water borne diseases were prevalent. Today, due to diversion of sewage from the lake, the extension of the intake tunnels, the chlorination of the water supply, and other factors, these diseases have practically disappeared.

While Chicago's population is but 3,000,000 people, the sewage equivalent due to industrial wastes is that of a city about 50% greater. Of this total, at the present time the sewage from 40,000 people receives complete treatment, that from 175,000 people partial, preliminary treatment, and a plant is now under construction to provide complete treatment for an additional 800,000 people. The remainder of Chicago's wastes is carried away by the drainage canal.

Rail and Water Terminals

The following recommendations look to relief of present serious conditions relating to the rail and water terminal situation:

1. The requirements of the expansion of the commercial district of the city to the south and the need for free circulation of through north and south traffic make necessary in the public interest the early straightening of the South Branch of the Chicago River and the subsequent rearrangement of the terminal facilities of the railroads entering stations located on the south side of the loop between Michigan Boulevard and the Chicago River, in such a way as will permit the opening of the additional streets as badly needed and the unrestricted development of commercial improvement.
2. The Port Commission of Chicago should take steps at once to comply with the provisions of the city ordinance creating it, i. e. make a thorough study of the local water terminal situation and report to the City Council its recommendations for the establishment of a permanent port authority and the adoption of a port policy and plan.
3. The City Council should take appropriate action with reference to the recommendations of the Port Commission to the end:
   a. That a permanent port authority be created to administer the affairs of the port.
   b. That the Chicago River bridge situation be relieved at the earliest opportunity.
   c. That provision be made for necessary terminal facilities for the Illinois Waterway.
   d. That plans be made for such future harbor development as may be anticipated will be required.
   e. That areas suitably located and of sufficient extent to care for harbor expansion for a great many years be reserved and protected from encroachments which will prevent their being used for harbor purposes should they be required, and that no grants be made to a limited number of interests which would restrict the developing of such lands.

It is expected that the rail-borne traffic will continue to increase more or less in direct proportion to the growth of population and business. This will necessitate the expansion of some of the existing

facilities in their present locations as their capacity is reached and, where congestion seriously affects the conduct of business, the removal of others to less congested districts. There is little doubt but what the railroad will take care of the expansion or relocation themselves to the extent believed justifiable from their point of view.

However, it does not follow, necessarily, that facilities which are satisfactorily located as far as the railroads are concerned and capable of being enlarged in their present locations but which seriously interfere with civic expansion will be rearranged or relocated so as to permit a healthy growth of a city. Quite properly the city tends to expand laterally to the north and south. The lake front is influential in bringing this about for being the city's greatest natural attraction it guides the direction of intensive residential occupation while the commercial district is expanding vertically. The city is about twenty-six miles long to seven miles wide. Each year brings a tremendous increase in residential population to the north and south so each year there is a marked increase in traffic in a north and south direction.

The necessity of removing obstacles to this north and south movement is therefore apparent. The South Branch of the Chicago River constitutes a serious obstacle in this respect for it bends eastward in such a way as to jam the four north and south through streets into an area overloaded with old fashioned railroad terminal facilities. The latter in themselves are obstacles of no small proportions for though freight and passenger terminals, yards and approach tracks may be depressed or elevated so that through streets may be provided over or under them, the terminals themselves are centres of congestion; cabs, street cars, automobiles, trucks and pedestrians, all seeking access to or egress from the terminal area produce a condition which makes the through movement of traffic well-nigh impossible. A change in the type of terminal improvements is therefore indicated.

The completion of the Illinois Waterway will introduce a new set of conditions into the solution of the local terminal problem. Industrial freight will more or less take care of itself for large industrial users of the waterways located on one of its feeders will probably find it profitable to construct their own cargo handling equipment. Self-unloading boats will meet the requirements of the smaller users of bulk materials. But for the shipper or consignee not located on the waterway or one of its feeders, public terminals will be required.

The Chicago River bridge situation is an example of an acute conflict between terminal requirements and civic expansion —but unlike the case of the railroads occupying terminals on the south side of the loop, the carriers in this instance are suffering as well as the city and should benefit materially by any wise solution. The elimination of this particular conflict is one of the most important tasks confronting the city at the present time.

There appear to be no grounds for assuming that anything but normal growth in lake traffic will take place in the next decade or so. The demand for sites for new industries may result in a scarcity of locations along the Calumet River, which may require the development of Lake Calumet Harbor, but aside from that possibility, and the extreme desirability of putting the Municipal Pier in condition to do business efficiently, no physical changes of importance may be required except perhaps those made in anticipation of the permanent closing of the bridges over the Chicago River.

The St. Lawrence Waterway may not be completed within the next decade; however, a new set of conditions will be superimposed upon the local terminal situation if full advantage is to be taken of this improvement. These conditions should be anticipated by wise planning and by reserving areas suitable for harbor sites.

Public Welfare

All phases of community development must be considered in the light of their probable effect on the welfare of the people. The chief function of this city as a whole is not merely to provide a means for the creation and accumulation of wealth but rather to enable its citizens, in every walk of life, to lead their lives in reasonable health, safety, and comfort.

The following recommendations are

particularly important for public health and safety:

1. Zoning restrictions should be continued and in some respects strengthened, to prevent further congestion and to conserve both human health and property values.
2. Public health also demands adequate sunlight, air, and freedom from over crowding in all occupied buildings, as well as recreation facilities and bathing beaches and pools.
3. Traffic accidents must be held to a minimum by speed limitation, extension of traffic control, playgrounds to keep children off streets, safety education of children and adults, and eventual separation of grades at railroad-street crossings.
4. Co-ordinated plans for the entire Chicago region should be developed.

Zoning and Housing

Healthful and comfortable living are impossible in a crowded tenement house district—and many of the "apartment houses" of today are the tenements of tomorrow. Present housing and zoning ordinances furnish only a beginning toward the improvement of the conditions which have been permitted to develop. The following principles are believed to be essential:

(a) The principle of zoning should be firmly maintained.
(b) The restrictions on percentage of lot area that may be covered, and height or bulk, in all classes of residential districts, should be strengthened, not weakened.
(c) The number of families per acre should be limited, especially in new residence districts.
(d) The requirements for health and safety in existing dwellings should be strengthened, and strictly enforced.

Public Health and Sanitation

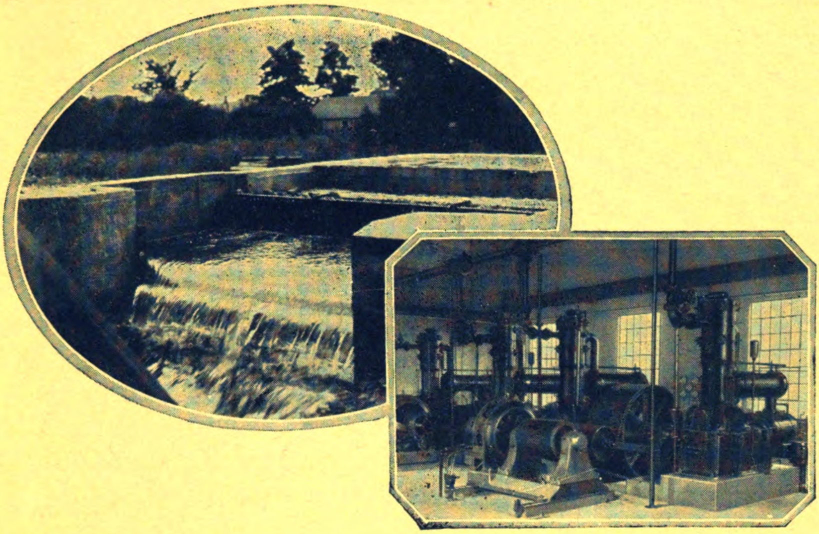
In addition to the provision of decent housing, the requirements for public health include the following:

(a) Adequate sunlight, air, and freedom from overcrowding are as necessary in business as in residential buildings, and on the streets, if increases of respiratory diseases are to be avoided.
(b) Working conditions in the industries, particularly with reference to light and air, should be greatly improved.
(c) Recreation facilities, such as public bathing beaches and in-and-out-door swimming pools, must be much more extensive to eliminate the evils of congestion, or they must be made sanitary by artificial means.
(d) Pollution of water supply must be prevented as far as possible.
(e) Many buildings must be improved or rebuilt to provide against rat infestation.

Prevention of Street Accidents

Of the nearly 2,000 accidental fatalities in Cook County annually, more than half are associated with traffic; the annual economic cost of all accidents in the county exceeds $50,000,000. Requisites for improvement include:

(a) Reconsideration of the street system to meet modern traffic demands, including better planning of the through street system.
(b) Strict limitation of vehicular speed to that which is safe under the existing conditions.
(c) Adequate traffic control should be extended to a greater number of intersections, especially on the through streets and boulevards.
(d) More playgrounds should be provided to keep children off the streets and such playgrounds should not be on or near heavy traffic thoroughfares.
(e) Safety education of children in the schools should be encouraged also education of the general public to the necessity for personal carefulness, and for mutual consideration on the part of drivers and pedestrians.
(f) A long-time program looking toward eventual separation of all railroad grade crossings in the city should be adopted.
(g) Excessively high buildings should be discouraged because they increase street congestion and hazards, in addition to their fire hazard to occupants and their harmful effect in cutting off light and air from others.



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JOURNAL OF THE
WESTERN SOCIETY OF ENGINEERS

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Annual Meeting Closes Fiscal Year

This issue of the Journal goes to press on the eve of the Annual Meeting. A good program has been arranged and at the rate the reservations are coming in it is predicted that a successful and interesting meeting will be held.

The two outstanding events in the evening will be the presentation of the Washington Award and conferring the Chanute Medals for the best papers presented before the Society, one of which will be received for his family by the son of Dean Hayford who died last spring. The Annual reports to be presented showing the progress of the Society are unusually favorable.

A complete account of the Annual Meeting will appear in the next issue of the Journal. Following is the program:

PROGRAM

Reception 6:00 p. m. . . . . . . Dinner 6:30 p. m.
Music by Cope Harvey's Orchestra
President's Address . . . . Elmer T. Howson, Pres.
Response . . . . . . Homer E. Niesz, Pres. Elect.
Presentation of Washington Award . D. H. Maury, M. W. S. E.
Response . . . . . Jonas Waldo Smith, C. E., D. Eng.
Presentation of Chanute Medals for best papers read in 1924
Address, Hon. James H. Wilkerson, U. S. District Judge, Chicago
Wm. Longstreet, Soloist — Jack Jones, Accompanist
George Simpson, Entertainer

New Officers Elected

The Board of Direction received the report of the Judges of the Election at a special meeting on May 20, as directed by the Constitution. The new officers will assume their duties immediately upon the announcement of their election at the Annual Meeting.

The report of the Judges of Election is as follows:

Election of Officers, 1925

To the Board of Direction,
Western Society of Engineers,
Gentlemen:

The Judges of Election report the canvass of ballots for officers as follows:

Total Ballots received		611
Void—No signature	12	
Non-Corporate	2	
Delinquent	1	
Defective (Blank)	17	
Deduct Total Void		32
Total Ballots counted		579
For President	total 578	
Homer E. Niesz	578	
For 1st Vice Pres.	Total 575	
F. E. Morrow	575	
For 2nd Vice Pres.	Total 573	
Major R. W. Putnam	573	
For 3rd Vice Pres.	Total 573	
John A. Garcia	573	
For Treasurer	Total 575	
Geo. W. Hand	575	
For Trustee (Three Years)	570	
Frank D. Chase	570	
For Member Washington Award: Commission		
Elmer T. Howson	566	
R. F. Schuchardt	566	

(Signed) Jos. E. Love,
N. H. Camp,
Royal C. Wise,
Judges of Election.

Unusual Lighting Effects Required

"Spectacular Illumination" was the subject of the meeting of April 20, at which D. W. Atwater, Illuminating Engineer, Westinghouse Lamp Co., New York, was the speaker. This was a joint meeting with the Chicago Section, Illuminating Engineering Society.

In introducing his subject, Mr. Atwater, brought out the fact that although there are comparatively few occasions when this kind of lighting is used, those occasions are largely judged by the effects produced in the decoration. Such things as conventions, sometimes include a large appropriation for lighting and decorations.

The means to be employed are only two, namely, the use of lamps in such a way that the light source itself is visible or the use of reflecting units which throw the light from concealed sources upon decorations to be illuminated. Mr. Atwater exhibited a collection of pictures of a number of large conventions where these means have been employed. The use of the reflecting apparatus or what is commonly known as "flood lighting" is becoming more popular and it is producing some remarkable results. In fact this type of lighting is being adopted for permanent use to illuminate objects of particular beauty at night, so that they may be enjoyed by a larger number of people, than if they were only visible during the daytime. For example, the Lincoln Memorial in Washington, and many of our permanent buildings, are now being lighted by reflecting apparatus. Here the use of color is producing remarkable effects, some of which are considered beautiful and others not so attractive.

A development which Mr. Atwater described is the use of artificial light for outdoor sport, such as football, golf and tennis. When properly designed equipment is used, this can be accomplished with entirely successful results. An interesting development is the acceleration of growth of the grass on a putting green by concentrating a flood of strong artificial light upon it at night. Greens are thus made ready for use in half of the time required heretofore.

Largest Rock-Fill Dam

The world's largest rock-fill dam, which is a part of the new hydro-electric development on the Dix River in Kentucky, was described at our meeting of April 27th, by its designer L. F. Harza, M. W. S. E. His paper entered into a discussion of the different types of dams that might be available for this particular site and analysis of the comparative merits of each.

At this location the Dix River cuts through a rocky gorge which however, is too wide to permit the use of an arch type of dam. The desired height, namely 275 feet was far beyond precedent for the arch types, gravity section, or hydraulic fill. An abundant supply of rock was at hand, some of which could be blasted, so as to fall directly in the desired location. These conditions indicated the use of the rock fill type.

Mr. Harza reviewed his investigation of the existing rock-fill dams, which showed the stability of this type. The three essential elements to be considered are; an ample spillway, conservative slopes and a flexible, water-tight diaphragm, sealed into bedrock. He showed a large number of lantern slide illustrations of the work in different stages of construction, each illustrating some point brought out in his description of the design details. This particular dam is 275 feet high and more than 1000 ft. long. It impounds more than 300,000 acre-feet of water in a reservoir about 36 miles long. This reservoir will submerge several highway bridges and the waterworks of the city of Danville, Kentucky, all of which had to be rebuilt.

The details of Mr. Harza's paper will be given in full in the technical section of our Journal in a subsequent issue.

Relieves Congestion on New York Central Lines

One of the largest railroad construction projects of recent years was described at our meeting May 5, by W. F. Jordan, Prin. Asst. Engineer, N. Y. Central Lines, who read a paper on the "Hudson River Connecting Railroad." This project is familiarly known as the Castleton Cut-Off. It is so large that each

of its component parts has been given considerable individual attention. Included in the project are a freight yard with initial capacity of 11,000 cars and ultimate capacity of 20,000, 26 miles of double track railroad and a steel bridge one mile long spanning the Hudson River.

It was necessary to do something to relieve the congestion which existed at Albany, due to draw-bridge and grade crossing interference and to the heavy grades encountered in passing over the old line. It has been calculated that the direct saving of 120 ft. of rise and fall for all traffic and of more than 450 train-miles per day because of shortening the lines will pay the additional capital expenses, to say nothing of the great benefit derived from increased capacity and efficiency of the entire system.

The Albert H. Smith Memorial Bridge over the Hudson River, is one of the outstanding features of this development. It contains one span of 600 ft., one of 400 ft. and something over 4000 ft. of approaches on 100-ft. spans.

Construction of the bridge was a particularly interesting piece of work. The unusual size of some of the members introduced some complicated construction problems. Some trouble was encountered in driving the one inch and one-and-one-eighth inch rivets. After considerable study and experiment, a method was developed which resulted in a tightly driven rivet which completely filled the holes.

This paper is especially commendable because it included a description of some of the mistakes that were made and analysis of the conditions which led to their correction. The unusual soil conditions encountered at this location made it impossible to foretell just what was likely to happen. For example, some of the excavated material was so unstable that it would not remain in the embankment without support. The treacherous character of the material encountered in the river bed caused some trouble in the excavation for the bridge foundations.

A number of prominent railroad engineers and members of the Society gave a dinner for Mr. Jordan at the Chicago Engineers Club before the meeting.

Engineers in Public Service

Major Alexander Forward, Secretary Manager, American Gas Association of New York, addressed the members of the Society at a meeting held May 11 on the subject "Engineers and the Public Service." In his present connection and from his former work as vice president of the National Association of Railway and the Utilities Commissioners, Maj. Forward has had an unusual opportunity to observe the work of engineers in public service.

In his address he recounted a number of important examples of the service given by engineers in promoting the public welfare. Examples were given of the advance made in transportation, communication, manufacture, public health and many other fields of endeavor where the contributions of engineers have been remarkable.

Maj. Forward ventured a prediction that there will be revolutionary changes in the production and use of heat both for domestic and industrial uses. He called attention to the fact that the present wasteful method cannot long continue without exhausting our supply of desirable fuel. Here as elsewhere engineers are called upon for constructive work which results in continued advance of civilization.

"Protective Relays"

"Protective Relays" was the subject of a paper read before the joint meeting of the Society with the Chicago Section, American Institute of Electrical Engineers in our rooms May 18, by O. J. Bliss, Asst. Chief Testing Engineer, Commonwealth Edison Co., Chicago. The size of the audience which filled our rooms to capacity is an indication of the importance of this subject in electrical engineering.

Every engineer knows that electrical circuits must be protected to prevent damage resulting from accidents or defective material. The protection of a large network as used in a metropolitan system becomes a rather complicated problem.

Mr. Bliss, who has specialized on relays for many years, first described the principle types of relays that are

available and then showed how each is used to accomplish a desired result under certain conditions. The number of combinations that may be used is almost infinite, which makes it possible to pick out a system of relays that will accomplish practically any desired result. The important thing is to determine the type of relay that is required and will do the thing that is expected of it. The record of performance of relays in the service of the Commonwealth Edison Co. for the past four years, shows an increasing precentage of perfect operation which has now very nearly approached 100%

Reports On Tornado Damage

The last technical meeting of the year, held May 25, was one of the most interesting that we have had this year and presents the practical working out of an idea that we predict will lead to some valuable work being done for the Society and its members. This meeting was the occasion for presenting a report prepared by the members of the Executive Committee of our Bridge & Structural Section, who deserve a large amount of credit for the work that they have done.

Shortly after the tornado of March 18th, in the southern part of Illinois the committee decided to visit the storm area for the purpose of studying the damage done to structures and, if possible, determining what could be done to design buildings that would better resist damage by windstorms. Accordingly four members of the Committee namely: Hugh E. Young, Frank A. Randall, F. G. Vent and Max Loewenberg, visited the area on March 28 and 29. Preparations had been made so that they were given access to desired points. They took over a hundred photographs which were used in making up their report. The remaining member of the committee, J. B. Schaub, was unavoidably detained, but contributed largely in the work of preparing the report.

The report which was presented May 25 first gives a very complete analysis of the meteorological conditions giving rise to tornadoes and a study of their frequency. It has been said that a cyclone never strikes twice in the same place, but a map of the Mississippi Valley Region with the paths of tornadoes placed thereon, shows the central part of the Mississippi Valley to be particularly likely to be visited by these storms.

The actual velocity of this storm was 60 miles per hour, while the wind velocity necessary to do the damage that was done, must have been several hundreds of miles per hour. The difference is accounted for in the rotating motion. This part of the report was presented by Mr. Schaub.

Frank A. Randall presented the second part of the report which was a description of the damage done to the structures inspected. This was illustrated with about 75 lantern slides. The description of the different building failures was accurate and complete. It was presented in such a manner as to give the audience a very clear picture of the conditions being described.

The third section of the report was the analysis of data collected and statement of conclusion. This was presented by Hugh E. Young, Chairman of the Section and was illustrated with a number of drawings. This part of the report analyzed the stresses in a steel water tank which was blown over. The analysis of this structure indicated the need of stronger diagonal bracing rods and more careful anchorage to foundation. A similar analysis was made of a concrete chimney adjacent to the water tank which stood throughout the storm.

The report analyzed the four principal types of building construction with reference to their ability to withstand such storm. For this analysis buildings were classified as ordinary frame construction, ordinary brick walls with frame joists and girders, mill type or slow-burning construction, fire proof construction and miscellaneous structures. Consideration of each of these types shows that there are certain minor precautions that can be taken in the design and construction, such as securely bolting sills to foundations, roofs to side walls, joists to walls and also tieing the corners properly, which add a very small amount to the total cost but greatly increase the ability of the building to resist windstorms. In every case the structures examined showed that the points of weakness would have been comparatively easy to strengthen.

Among its conclusions regarding special structures such as water tanks the committee recommended that a designing wind pressure of 65 lb. per sq. ft. be used with a factor of safety of four and that the weight of structure be divided by a factor of safety of four before entering the weight into the calculation for stability. Special consideration was recommended to be given to anchorage and wind bracing as these are details that can be strengthened at comparatively little cost and seemed to be points of first failure.

It has been suggested that each one of the technical sections of the Society could well undertake investigation of one or more subjects lying within the field of their work in a manner similar to this one. There are undoubtedly a number of debatable questions in every field of engineering which might be made the subject of investigation and report. They would be all the more valuable if those reports served to bring careful discussion. Unfortunately there seems to be too much of a tendency to accept whatever an author says about a subject, without making any attempt to investigate or verify it. Sometimes the discussion is as valuable as the paper itself.

Forum Hears Famous Coach

Robt. C. Zuppke, famous football coach at the University of Illinois, was the principal speaker at the Second Annual Dinner of the Young Men's Forum, held at the City Club, May 6th, 1925. This choice of a speaker for a young men's organization was especially fortunate and assured the success of the evening's program.

This was an evening of good fellowship which started off with several vocal and instrumental numbers, rendered by some of the boys from Armour Institute, during the excellent dinner served by the Club. After dinner Robert Carr, President, Dearborn Chemical Co., was introduced as master of ceremonies. His cordial remarks served as a fitting introduction to the speaker of the evening.

Coach Zuppke is a remarkable man and it is easy to see why he has become such a successful leader. He says exactly what he thinks, without fear of any consequences. He talked in a manner entirely informal without attempting to follow any definite line of reasoning, but pointing out some of the reasons why athletics take such an important place in college life.

He pointed out that one of three principles, namely, the desire to eat, to love or to fight, governs nearly everything we do. Athletics persist in college because of the spirit of adventure evident in youth. There is no denying the fact that athletics promote good health. Individual stars become popular because by nature man wants to have a hero that he can admire.

Intercollegiate athletics have become a great force in breaking down provincialism and establishing better relations in different sections of the country. To the individual, athletics tend to break down an inclination to only half do things. Football in particular is a game which must be played thoroughly. It is called a brutal game but cannot be played by brutes, as it requires a keen mind and a clean body.

Coach Zuppke introduced so many humorous remarks in the course of his talk that he kept his audience in an uproar of laughter most of the time.

President E. T. Howson told the members of the Forum that membership in the Western Society of Engineers is considered as a recognition of certain professional qualifications, which are valuable to a young man starting out in a profession. He reviewed some of the activities of the Society and mentioned the awards which it maintains in recognition of achievement in the profession. He said that no profession can hope to rise higher than the level of its individual members. President Howson expressed the hope that the Forum will continue to prosper and assured the members that the Board of Direction is willing to co-operate to the fullest extent at all times.

The Forum is to be congratulated on the success of this dinner meeting. The Committee in charge, which consisted of C. J. Michelet, F. A. Hess, R. B. Bohman, L. M. Traiser, Willis Rabbe, E. W. Atkison, W. K. Flavin, and D. T. Waby, worked hard to make the event a success and their efforts were well rewarded.

Forum Discusses Calumet Harbor

John W. Woermann, M. W. S. E., U. S. Assistant Engineer, Chicago, addressed the Young Men's Forum April 22 on the subject of the proposed Lake Calumet Harbor. Mr. Woermann is very familiar with this project and was Chairman of a special subcommittee appointed by the Waterways Committee of the Society to prepare and present a report on the ordinance now pending before the City Council, an account of which appears in another column.

Lake Calumet covers an area of 2300 acres, to an average depth of less than 3 ft. It is situated six miles from Lake Michigan through the Calumet River. The State Legislature has authorized the City to construct an industrial harbor at this site. The City is without funds to undertake this construction and carry it through to a successful conclusion. The plan contemplates a Belt Line Railway surrounding the entire harbor and affording ample transfer facilities to all the rail lines establishing connections therewith. The N. Y. C. & St. L. Railroad Co. has offered to build the first unit of the proposed harbor, in return for certain reclaimed land which it proposes to use for yard and terminal purposes. This offer has been contested. It provides for construction of the first unit of the harbor without financial outlay by the city. It provides for the reclaiming of submerged land which will make valuable industrial property and also provides for an adequate street and rail access to the harbor.

The first stage of construction will be to dredge out a channel 250 ft. wide and 12,000 ft. long with ample turning basins and ten slips 450 ft. in width and of varying lengths providing 13.7 miles of dock space. The central basin or anchorage will later be widened to 1,600 ft. connecting with the Calumet River by a channel 300 to 500 ft. wide.

The Lake Calumet Harbor is a project of great importance to the City of Chicago. With the removal of most of our river commerce to South Chicago it became necessary to provide new terminal facilities or forfeit most of this commerce to other cities, more fortunate in this respect. The Lake Calumet Region is a focal point for railroads and freight traffic can be handled economically without conflict and without encountering the congestion prevalent in downtown Chicago. The Young Men's Forum was fortunate to have secured a speaker who was so well qualified to talk to them on this important development. Many members of the Forum went on the Inspection trip to this Harbor District last summer.

Chanute Medals Awarded

The special Committee appointed by the Board of Direction to consider the awards administered by the Society, other than the Washington Award, has presented its report to the Board of Direction recommending that the medals of the Chanute Award for the three best papers read before the Society during the year 1924 be conferred as follows:

John F. Hayford, for his paper on "The Establishment of Isostasy."

Paul L. Battey, for his paper on "Maintenance Requirements for the Mechanical Equipment of a Railroad."

Walter A. Shaw, for his paper on "Shall Public Service be Rendered By Regulated Monopolies."

The Committee found that the other Awards maintained by the Society except the Washington Award, which is administered by a separate commission were not complied with during the year 1924, so no awards will be made.

The Chanute Award was established in 1901 by Octave Chanute, then President of the Western Society of Engineers. In 1902 Mr. Chanute presented to the Society an endowment fund sufficient to defray the expense of awarding three medals annually, to be awarded to members of the Society. During the war, interest in these awards was allowed to lapse and the Board decided that this year, it should be revived. The Committee appointed to consider the matter consisted of Arthur L. Rice, Chairman and Prof. Fred A. Rogers, C. W. Gennet, Jr., W. W. DeBerard, and D. W. Roper.

Mr. Chanute was a remarkable man. He will be remembered for his work

THE CHANUTE MEDAL

in aviation, in fact, his scientific studies of heavier-than-air machines did much to establish the fundamentals of the science of aeronautics. Chanute Field, named after him is a living memorial to his pioneer work.

Approve Calumet Harbor Ordinance

The Board of Direction at a special meeting held May 20, approved the report of the Waterways Committee of the Society in reference to the contract ordinance between the City of Chicago and the Nickel Plate Railroad now before the City Council. This report was immediately transmitted to Mayor Dever who had not yet attached his signature to the ordinance, which was reported to have passed the City Council by a narrow margin.

The full report of the subcommittee, which gives a complete statement of the facts, is given herewith.

To The Waterways Comittee, of The Western Society of Engineers:

The Special Subcommittee of four members, appointed by the Waterways Committee at its meeting of December 12, 1924, to report on the Lake Calumet Harbor and the proposal of the Nickel Plate Railroad to build a Belt Line surrounding this harbor, have reviewed the proposed ordinance, attended a public hearing on this ordinance held in the Council Chamber on February 5, 1925, and held four Subcommittee meetings. Two reports on the subject are submitted for the consideration of the Waterways Committee with a view of formulating recommended action by the Society. The following report is presented by the majority of three members of your subcommittee; the minority report is attached herewith.

Lake Calumet is a shallow body of water situated in the southeasterly, industrial section of the City of Chicago. The lake is about three miles long, one and one-half miles wide, and has a circumference of approximately seven miles. Its area is approximately 2300 acres, with an average depth of less than three feet of water. Via the Calumet river, it is six miles miles distant from Lake Michigan, and a channel 200 feet wide and 21 feet deep is available from Lake Michigan to Lake Calumet.

Plans for the development of this lake as an inland harbor were undertaken in 1908 by a Harbor Commission created by the City Council. In 1913, the Legislature passed an act and authorized it, among other things, to build, own and operate harbors and harbor facilities, and to acquire riparian rights. On July 15, 1915, the City Council passed an ordinance accepting the grant from the State and creating Habor District No. 4 to include Lake Calumet and all of the Calumet River within the city limits. In 1921, the State granted to the City all right, title and interest of the State in and to the bed of the lake and abutting reclaimed lands except such submerged lands as would be comprised in the waterways of the new harbor.

On July 22, 1921, the City Council, by ordinance, accepted the provisions of the 1921 Act of the State Legislature, and adopted the Van Vlissingen plan for an industrial harbor, as embodied in the ordinance. This plan calls for the dredging of an anchorage basin 1600 feet wide, 12,000 feet in length, facing which are twelve slips of uniform width of 450 feet. All dredging to be done to a depth of 21.3 feet below Chicago datum. The plan further contemplates that a belt line railroad and highway adjacent thereto, be constructed surthat the City would construct the belt line, provide for its operation, by the City, or by lease to the Pullman Com-

pany, or others, at the option of the City.

Considering the area within the center line of the encircling highway, the plan as adopted by the City Council provides for the following divisions and uses:

	Acres
Waterways	693
Streets and plaza	110
Belt Line and Railroad	87
Industrial sites	1254
Total	2144

Agreements have been made, under the grant of authority given by the State Legislature, with all owners of riparian rights with the exception of the Nickel Plate Company.

The proposed ordinance of the Nickel Plate Company, now pending in the City Council of Chicago, is a contract ordinance between the City and that Railroad Company. It establishes the boundary line between lands of the City of Chicago and the Nickel Plate Company, conveys railroad right of way and other lands to the Railroad Company, dedicates certain streets, provides for the construction and operation of a belt line railroad, the reclamation of certain lands and the construction of a portion of the proposed harbor in Lake Calumet. The ordinance marks the initial constructive step in the actual work of developing the industrial harbor which has been under active consideration for the past fifteen years, and for this reason merits the serious consideration of every citizen of Chicago. The Nickel Plate Railroad, by reason of its proposed terminal yard in the vicinity of the proposed Calumet Lake Harbor, is particularly well situated economically to take the initial step in this important development.

The proposed ordinance provides many constructive features requisite to the promotion of the future development of the area. It provides an initial unit of construction without financial outlay by the City. It settles a very important boundary line agreement. It assures the construction of a belt line railroad entirely surrounding the proposed harbor for transportation service to industries which locate in this area. It provides for the filling of submerged lands for the purpose of construction of public streets within the area. It does not, however, in the opinion of your Committee, properly provide for unrestricted transportation service, essential to the interests of the ultimate shipper and consumer, and for the economical development of the Harbor District.

Your Committee, therefore, recommends that this ordinance be amended by revising Paragraph 3, on page 14, relating to the operation of the proposed Belt Line, to read as follows:

(3) "Said Company shall make direct physical connection for the interchange of traffic with any railroad company that will extend its rails to a point on the said belt line right of way where such a connection may be practically made, and make a contract with any such railway company for its use of the proposed Belt Line Railroad. And said company shall file with the properly constituted Federal and State authorities all rules, regulations and privileges that in any manner affect the rates charged or to be charged for any service performed or for the use of the proposed Belt Line Railroad."

Your Committee suggests that further amendment of the ordinance be made on page 27 to include the following clause relating to the use of waterways by the Public or by State and Federal authorities:

> "That the navigable waters of Lake Calumet Harbor, including the Basin and Slips, shall be forever open to the full and free use of the public, subject only to such rules and regulations as may be prescribed or established by authorized Federal, State or Municipal authority."

With these amendments, your committee believes that by the acceptance of such an ordinance as amended, the City of Chicago will be greatly benefited, the Nickel Plate Railroad be encouraged in their proposed important terminal improvement in this vicinity, and the ultimate returns to the City as a whole, the shipper and consumer will be greatly enhanced, and your Committee would, therefore, recommend its acceptance and adoption on the part of the City Council of Chicago.

Approved—May 21, 1925.
Board of Direction,
Edgar S. Nethercut, Secretary.

Library Books at a Bargain

Following is a list of books, duplicating copies already on our shelves, which the Library Committee wishes to sell to make room for new material. These are offered to the members at a substantial reduction in price. The funds secured from their sale will be used to buy new books.

These will be disposed of before June 15, either to our members or to second-hand dealers. Members wishing to secure any of them should send in their order at once or see the Librarian. First come, first served.

American Institute of Mining Engineers. Transactions. v. 29-47, 1899-1913 19 v. Standard binding. Good condition $35.00

American Iron and Steel Institute. Year Book. 1915, 1917-22. 7 v. Red cloth. Like new 17.50

American Society of Civil Engineers. Transactions. 1921-23. 3 v. Black cloth. Good condition 6.00

Same 1921 unbound 1.00

Same 1922, black cloth, good condition 2.00

American Society for Testing Materials. Proceedings. 1918-20. 6 v. Index v. 13-20 1913-20. Standard binding. Like new 20.00

American Society for Testing Materials. Standards. 1918. Blue cloth. Like new .... .50

Association of Railway Electrical Engineers. Proceedings. v. 5-9 1912-16. 5 v. Dark cloth. Good condition 7.50

Electric Railway Review. Daily ed. 1907. Dark brown leather. Good condition .... Make offer

The Engineer. Chicago. v. 43-44. 1906-07. (In May 1908 incorporated with Power.) Black leather. Fine condition 4.00

Engineering-Contracting. v. 29-35. Jan. 1908-June 1911. 7 v. Black leather. Very good condition 15.00

Engineering News. Jan. 1882-June 1885. Sheep binding, pretty badly rubbed .... Make offer

Engineering News. Jan. 1901-Dec. 1909. v. 45-62. Black leather. Good condition 36.00

Engineering News. 1901-1909. 22 v. Black leather. Poor condition .... Make offer

Engineering News. Jan.-June 1901, Jan. 1902-Dec. 1911. v. 45, 47-66. Black leather. v. 45, 47-62 fine condition, v. 63-66 poor condition 38.00

Engineering News. Indexes (2) 1874-1890 Bound. Good condition; (2) 1890-1899 Unbound. Good Condition; 1900-1904 Bound. Good Condition; 1905-1909 Bound. Good Condition. Each 1.00

Engineering News and News-Record. 1912-1917, 1918-1919 (incomplete) 1920-23. Unbound with part of advertising removed. Have not been checked .... Make offer

Engineering News and News-Record. v. 75-79. Jan. 1916-Dec. 1917. 5 v. in 4. Green cloth. Good condition 8.00

Engineering Record. v. 53, 55-56. Jan.-June 1916, Jan.-Dec. 1907. Black leather. Bound without the Current News Supplement 5.00

Illuminating Engineering Society. Transactions. v. 10 Nos. 4, 5, 7, v. 13-17, 1915, 1918-1922. Unbound 12.00

International Congress of Applied Chemistry. 8th Congress. 1912, 29 v., Unbound 12.00

Railway and Engineering Review. v. 42-53. 1902-1913. 12 v. Black leather 28.00

Railway Signal Assn. Proceedings. 1904-1907. Unbound 4.00

Street Railway Journal. v. 23-26. 1904-1905. 4 v. Black leather. v. 23-24 have broken bindings. v. 25-26 good condition 6.00

Western Railway Club. Proceedings. v. 6, 8, 19-22, 24-25. 1893-1894, 1895-96, 1906-1910, 1911 1913 .... 12.00

Same v. 19-21, 1906-09. Black cloth. All good condition. Standard binding 4.50

H. L. Woolhiser, M. W. S. E. was elected Secretary of the Winnetka Rotary Club, April 17th. Mr. Woolhiser is Village Manager of the Village of Winnetka and is now busy supervising the building of a new Community House.

Additions to the Library

American Railway Assn. Telegraph and Telephone Section. Proceedings. 1924.

American Railway Bridge and Building Assn. Proceedings. 1924.

Canada. Dominion Water Power and Rĕclamation Service. Annual Report. 1923-24.

Engineering Index 1924.

Illinois Society of Engineers Annual Report 1925.

Illinois. State Water Survey. Bulletin 19, 1924. Solubility and rate of solution of gases: bibliography.

Institution of Civil Engineers. Minutes of Proceedings. v. 218. Feb. 1925.

North-east Coast Institution of Engineers and Shipbuilders. Transactions. v.40. 1924.

Production of petroleum in 1924. (A. I. M. E. Transactions. Paper No. 1447. 1925)

U. S. National Advisory Committee for Aeronautics. Annual Report. 1923. Includes Technical Papers No. 159-185.

RAILROAD MATERIAL—LOTHHOLZ COLLECTION

Holmes, F. L. Regulation of railroads and public utilities in Wisconsin. 1915.

Wymond, Mark. Railroad valuation and rates. 1916.

Hooper, W. E. Railroad accounting. 1915.

Wood, A. J. Principles of locomotive operation and train control. 1915.

Webb, W. L. Railroad construction. 5th ed. 1913.

Henck, J. B. Field-book for railroad engineers. 2d ed. rev. 1896.

Talbot, A. N. Railway transition spiral. 5th ed. rev. 1906.

Wilson, W. L. Elements of railroad track and construction. 2d ed. rev. 1915.

Hudson, R. G. and others. Engineers' annual. 1917.

Johnson, J. B. Theory and practice of surveying. 11th ed. 1895.

EARTHWORK—LOTHHOLZ COLLECTION

Cain, William. Earth pressure, retaining walls and bins. 1916.

Gillette, H. P. Earthwork and its cost. 3d ed. 1920.

Howe, M. A. Retaining walls for earth. 5th ed. rev. 1911.

CONCRETE—LOTHHOLZ COLLECTION

Adams, Henry and Matthews, E. R. Reinforced concrete construction in theory and practice. 1911.

Brooks, J. P. Reinforced concrete, mechanics and elementary design. 1911.

Hatt, W. K. and Voss, W. C. Concrete work. 1921.

Hool, G. A. and Whitney, C. S. Concrete designers' annual. 1921.

Taylor, F. W. Extracts on reinforced concrete design. 1910.

MECHANICAL DRAWING BOOKS from the LOTHHOLZ COLLECTION

French, T. E. A manual of engineering drawing for students and draftsmen. 2d ed. rev. 1918.

Weick, C. W. Elementary mechanical drawing. 1915.

Weick, C. W. Mechanical drawing problems 1917

MACHINERY—LOTHHOLZ COLLECTION

Colvin, F. H. Machine shop primer. 1910.

Kimball, D. S. Elements of machine design. 1910.

Smith, R. H. Text-book of the elements of machine work. 2d ed. 1916.

THEORETICAL MECHANICS—LOTHHOLZ COLLECTION

Bowser, E. A. Elementary treaties on analytic mechanics. 1920.

Glazebrook, R. T. Mechanics. 1918.

Wolfe, W. S. Graphical analysis. 1921.

Jansky, C. M. Elementary magnetism and electricity. 1914.

MISCELLANEOUS ADDITIONS—LOTHHOLZ COLLECTION

Dana, R. T. Handbook of construction plant. 1914.

Dibble, S. E. Elements of plumbing. 1918.

Goldman, O. B. Financial engineering. 1920.

Hazlehurst, J. N. Towers and tanks for water-works. 3d ed. rev. 1907.

Richey, H. G. Handbook for superintendents of construction, architects, builders and building inspectors. 1905.

Ricketts, P. de P. and Miller, E. H. Notes on assaying. 1897.

Rosenhain, Walter. Introduction to the study of physical metallurgy. 1915.
Sabin, A. H. Red lead and how to use it in paint. 1917.
Sample, J. C. Properties of steel sections. 1905.
Southern Pine Assn. Southern yellow pine; a manual of standard wood construction. 1917.
Webber, Edouard. Technical dictionary in four languages. 1898-99.
West Coast Lumbermen's Assn. Structural timber handbook on Pacific coast woods. 1916.

Calculus

Andrews, E. S. and Heywood, H. B. Calculus for engineers. 1914.
Barker, A. H. Graphical calculus. 1914.
Blaine, R. G. Calculus and its applications. 1913.
Carpenter, C. C. The A B C'c of calculus. 1922
Gould, E. S. A primer of the calculus. 2d ed. rev. 1899.
Bowser, E. A. An elementary treatise on the differential and integral calculus 25th ed. 1920.
Osborne, G. A. An elementary treatise on the differential and integral calculus with examples and applications. 1891.
Snyder, Virgil and Hutchinson, J. I. Differential and integral calculus. 1902.

ELECTRICAL BOOKS FROM THE LOTHHOLZ COLLECTION

Croft, Terrell. American electricians' handbook. 1913.
Croft, Terrell. Practical electricity. 1917.
Rowland, A. J. Applied electricity for practical men. 1916.
Timbie, W. H. Elements of electricity for technical students. 1914.
Bailey, B. F. The induction motor. 1911.
Bailey, B. F. The principles of dynamo electric machinery. 1915.
Croft, Terrel. Electrical machinery, 1917.
Hanchett, G. T. Alternating currents. 2d ed. rev. 1910.
Morecroft, J. H. Continuous and alternating current machinery. 1914.
Harding, C. F. Electric railway engineering. 1911.

BOOKS ON THE STRENGTH OF MATERIALS AND MECHANICS LOTHHOLZ COLLECTION

Boyd, J. E. Mechanics. 1921.
Church, I. P. Mechanics of internal work (or work of deformation) in elastic bodies and systems in equilibrium, including the method of least work. 1910.
Fuller, C. E. Applied mechanics. v. 1 Statics and kinetics. 1915.
Maurer, E. R. Technical mechanics, statics and dynamics. 4th ed. 1917.
Morley, Arthur. Mechanics for engineers. 1912.
Morley, Arthur. Strength of materials. 1921.
Seely, F. B. Analytical mechanics for engineers. 1921.
Slocum, S. E. Text-book on the strength of materials. 1906.
Slocum, S. E. The theory and practice of mechanics. 1913.

New Books

625.5
C323r
Railway electric traction.
By F. W. Carter. N. Y., Longmans, 1922. 412p. Illus., tables, diags.

The aim of the author in writing this book was to discuss the methods of electric traction as applied to railways and to expound methods of technical calculation applicable to the subject. Except where needed for purposes of illustration, descriptive matter has been avoided.

The material covered consists of: The locomotive, railway motors, motor control, distribution system, power equipment, systems of electrification, mechanics, and power supply. There is an appended table of locomotive statistics.

625.5
M289r
Railroad electrification and the electric locomotive.
By A. J. Manson. N. Y., Simmons-Boardman, 1923. 332p. Illus., tables, diags.

In the scope of this book it has been the aim to provide without too technical detail, information of value to anyone concerned with the operation, the maintenance and the repair of electric locomotives, or to anyone who in a general way is interested in the electrification of steam railroads. In addition to descriptions and illustrations of electric locomotive design and construction, there are included examples of the practical solution of problems as encountered in the electrification of existing railway properties. Numerous tables supply data covering electrified projects which are successfully operating throughout the world. There is also a brief history of the electrification of steam roads in the U. S.

620.1
S971s

Structural engineering. v. 1 Strength of materials.

By G. F. Swain. N. Y., McGraw, 1924. 569p. 1

The first volume of a series destined to treat of the theory and design of structures. The aim of this volume is to give a complete, clear and simple discussion of the fundamental principles of the strength of materials applicable in the design of structues of various kinds, not merely of framed structures, but of those of masonry and concrete also. It is believed to contain all that is necessary for machine design, also.

Chapter headings are: Mechanics; Behavior under stress and strain; Relations between stresses at a point; Pure tension or compression; Shearing; Torsion; Flexure; Influence lines; Beams; Riveted joints; Hollow cylinders and spheres; Columns; etc.

621.331
K29r

Report and recommendations on a comprehensive rapid transit plan for the city and county of Los Angeles.

By Kelker, DeLeuw & Co., Chicago. Los Angeles, 1925. 202p. 24 plates. Illus., maps, tables, diags.

A plan for transportation service for Los Angeles of the present and future. Suggestions for immediate construction (rapid transit, street railway lines busses and interurban) and for future construction to serve a city of 3,000,000 are made. The method of financing is outlined.

658.7
A389m

Management's handbook.

Edited by L. P. Alford. N. Y., Ronald Press, 1924. 1607p.

The first handbook dealing with scientific management. The purpose is to offer in one reference volume practical, working information on management for the use of executives, engineers consultants and students. It follows closely in treatment and style those features of engineering handbooks which have received general approval.

The book is divided into three sections: 1. General information of a fundamental character including tables, statistics, charts, graphs, management ratios, and mathematics. 2. The discussion of established management functions—the plant and its layout office methods, forms, handling of materials, time keeping, etc. 3. Basic information on the economic principles underlying industry—budgetary control, cost accounting, analysis of markets for distribution, etc.

658.7
161

First international management congress. Prague. 21-24th July, 1924.

Papers. Prague, Masaryk Acad., 1924. Pamphlets.

A collection of short papers by international authorities on diverse subjects in the field of industrial management. Industrial research standardization, budget control, railway management, and engineering education are a few of the questions discussed.

531
S823f

Four lectures on relativity and space.

By C. P. Steinmetz. N. Y., McGraw, 1923. 128 p. Illus., diags.

An explanation with simplified mathematics intended for the layman. Contents: Lecture 1. General discussion of relativity of motion, location and time, length and duration, mass, etc. Lecture 2. Conclusions from the relativity theory. Lecture 3. Gravitation and the gravitational field. Lecture 4. The characteristics of space.

620.1
129

Power studies in Illinois coal mining.

By Arthur J. Hoskin and Thomas Fraser. Prepared under a co-operative agreement between the Engineering Experiment Station of the University of Illinois, the Illinois State Geological Survey, and the U. S. Bureau of Mines. Urbana, Univ. of Ill., 1924. 82p. Map, tables, diags. (Univ. of Ill. Eng. Exp. Sta. Bull, 144)

A very important compilation of data on the kinds of power used, whether generated by the mine or purchased, and the amount consumed by various mining activities: There is also a classification of power costs, and a study of factors that affect power costs in mining.

625.7
B559

City pavements.

By F. S. Besson. N. Y., McGraw, 1923. 421p. Illus.

Discussion of the various types of pavements: concrete, bituminous brick, stone block, wood block and asphalt block, with specifications, tests, and cost data. There is a preliminary chapter on administration and management, planning and design and a final one on trees for city planting.

620.1
U59t

Fire resistance of concrete columns.

By W. A. Hull and S. H. Ingberg. Washington, 1925. 73p. Illus. (Bureau of Standards Tech. Papers 272)

Shows results of fire tests made on 62 columns under working load, some with protective coatings, others without. The wide difference in fire effects was determined as due in large part to difference in mineral composition of the concrete aggregates used. Shape of section or type of column reinforcement were shown to be of minor importance.

621.3198
T636p

Protective relays. Their theory, design, and practical operation.

By Victor H. Todd. N. Y., McGraw, 1922. 274p. Illus., diags.

Attempt has been made to cover the subject from the first principles to the protection of high tension transmission networks, the object being to make the work of value not only to the operator and tester, but also to the designer of the system.

Handbook of telephone circuit diagrams with explanations.

By John M. Heath. 279p. Diags.

A detailed compilation of the circuits which comprise a telephone system with explanations of how they work. The book brings together in convenient form the sound principles of manual telephony, both local battery and common battery as known to-day.

Book Review

Detailing and fabricating structural steel.

By F. W. Dencer, Engineer Gary Plant, American Bridge Co. N. Y., McGraw, 1924. 511p. Illus., tables, diagrs.

The author has described in a thorough and comprehensive manner the progress of structural steel fabrication through the drawing room and shop up to shipment, with a consideration of the economic features of each step involved.

Plant and drawing room organization and practices are outlined. An extended classification is made of the wide range of work handled by the large structural steel shop of today and the work of the drawing room in the following main divisions is treated in detail:

Bridge Works, Office Buildings (including apartments, hotels, factories, etc.), Mill Buildings, Machinery for Bridges and Tank Work. The fabricated ship and export work are touched upon. Under each of the above headings profuse examples of shop drawings and details illustrate the various parts of the structure.

The latter half of the volume is devoted to the work of the shop from the mill order, the receiving and routing of material through the various operations of templet shop, laying out, punching, reaming and drilling, shearing, fitting riveting, forge and machine shop, finishing, shop inspection and shipment. All the various tools and machines used in these stages of the work are described and illustrated.

The closing chapters on Economical Fabrication and Drawing and Shop Errors are particularly instructive.

Good engineering is not lost sight of at any time and the book is a valuable addition to the library of all engineers who have to do with steel construction, as a practical knowledge of shop practices is essential to economic design.

F. A. R.

M. M. Fowler, M. W. S. E., has been elected one of the Board of Managers of the American Institute of Electrical Engineers. There are twelve managers on the Board of Directors of the Institute, three of whom are elected each year, to serve for a four year term, beginning August 1. Mr. Fowler was elected an Associate member of the Institute in 1903 and became a member in 1922. He has always been interested in its affairs and his election is a fitting recognition of his faithful service.

Has Narrow Escape

W. W. DeBerard, M. W. S. E., was one of the party of engineers on board the steamer "M. E. Norman," which capsized in the Mississippi River, twelve miles south of Memphis, May 8, resulting in the loss of 22 lives. Among those lost were 12 engineers who had been attending the First Annual Convention of Engineers of Mid-south. All were members of the American Society of Civil Engineers.

Mr. DeBerard's personal account of the accident, which is taken from the Engineering-News Record is as follows:

The river excursion came at the end of the convention. Over a hundred of the engineers and their guests embarked at Memphis in the afternoon on two typical Mississippi River steamers, the "Choctaw" and the "M. E. Norman" to inspect the revetment and mattress work at Cow Island Bend. On the way back the "Choctaw" took the lead and reached Memphis safely. En route the "Norman" started listing to such an extent that the passengers were called upon several times to trim ship. The accident took place suddenly, however, at a time of calm and when the vessel was in not overly swift current near Coahoma Bend. The sequence of events can best be described by a personal account.

Personal Account of Accident

We were in the cabin of the "Norman," about twenty of us, deliberating over the question of forming a local section of the American Society of Civil Engineers. Paul Norcross had just made an impassioned plea for members of the society to recognize the transitory nature of our existence and our duty to younger men by local service. Professor McNeilly also pleaded for help for the young man from his elders. J. H. Haylow, president of the Memphis Engineers Club; John F. Coleman, C. H. West, A. M. Lund and Prof. Kirkpatrick, had all urged action from altruistic considerations. L. L. Hidinger, was about to propose the formation of the section when all proceedings stopped. A cry went up to the assemblage to shift to the high side of the boat. This was around 5 p. m. Since this same order had been given twice before, no one was

flurried or felt uneasy; all started to comply. The engineers with clear-headed rapid precision turned within a few seconds to lightning-like physical decisions meaning life or death to family or friends. There was no hysteria, no complaints, no ifs, ands or buts, only plain action, duty and heroism of highest type, for not a report has reached any one of any but unselfish acts.

Before it was possible to move far, however, the boat continued to list with the lower side awash and everybody in the assemblage rushed out of an enclosure at the bow of the boat through a screened-in portion outside of this first enclosure. The boat listed so fast that few were able to adjust the life preservers, and most of those who had not already jumped were precipitated into the water. This action probably did not take longer than 30 seconds.

Practically everybody except three or four men had leaped from the high side of the boat. As for myself and the three or four men who had been catapulted into the water from the lower side of the boat, we swam for perhaps three minutes, picking up floating debris, and then made our way to the boat which had turned turtle, and managed to get hold of the upturned hull. Soon, however, a cry went up that the boat was going down by the stern, and this action and a rolling motion precipated those of us on the bottom of the boat a second time into the water. I grasped a life boat which had turned turtle, rode that for a few minutes, and on the instruction of Major Gillette, cut one of the hawsers which held the life boat to the large boat. This released a number of preservers which were in the boat, but almost immediately the large boat sank, and other life boats were sufficiently entangled so that they and the one I was on sank with it. Thus I was precipitated for the third time into the water. Luckily, oars in the life boat floated at hand and I grasped three of them which carried me safely for the next hour.

A motor boat providentially, was passing near the "Norman" when it capsized. To Tom Lee, a negro workman of the Tennessee Construction Co., who was in this motor boat, probably 90 per cent of the survivors owe their lives. The boat cruised back and forth among the floating survivors, picking up the women first and carrying them to shore, where fires were built and where some shelter was found in a cabin. Some of the survivors walked through underbrush and swamp to the nearest telephone where aid was called from Memphis. Most of the survivors reached Memphis that night by boat and so far none has reported any ill effects of the accident.

As a personal note I can remark that floating down river with three oars is a hardship only in that cold caused cramp which passed as I straightened my legs. After going ashore on the bar, warm sand served as first aid before the mile walk to the first bonfire helped start circulation. The editorial instinct came back at the bonfire where the prime essential of getting the names of relatives asserted itself. Though my camera had been lost I discovered a film roll undamaged in my pocket and from it there were produced ten good pictures, thanks to the quick and efficient development work by the Memphis Commercial-Appeal. By the time reporters arrived the list was completed so they lost no time in getting under way back to phone connections. I begged to go along so I could check up on their observations.

Prof. Dorroh's experience paralleled my own, in that in rushing to the top deck, the pilot house passed over him. His 14-year old boy scout son was one of the few who swam ashore unaided. James Wood and his wife were aft on the boat and not in the meeting. They merely walked dry shod around the boat as it rolled. Mr. Wood says that when it went down by the stern he swam, holding up his wife a few minutes until Tom Lee got them.

Errata

In the notice of election of new members, published in the April issue of the Journal, Joseph Klecka of 711 Diversey Parkway, Chicago and William D. Shipman of Franklin Park, Ill. were shown as having been elected to the grade of Student. This was an error which we take this opportunity of correcting. Both of these gentlemen were regularly elected Associate members on March 16.

Heads Board of Education

Col. E. B. Ellicott, M. W. S. E. has just been elected president of the Board of Education of the City of Chicago, a position which by virtue of his varied experience he is well qualified to fill. Col. Ellicott, became a member of the Western Society of Engineers, Aug. 6, 1900.

He was born in Hartland, N. Y., March 28, 1886 of pure American stock, his family originally having come to this country in 1658. He has been identified with the electrical industry in one way or another almost continuously since 1888, when he was made superintendent of the Concordia Electric Light Co. He was with the Western Electric Co. from 1891 to 1897 and then became city electrician of the City of Chicago which position he held for eight years. He was chief mechanical and electrical engineer of the Louisiana Purchase Exposition in St. Louis, 1904 and chief engineer Sanitary District of Chicago 1905-1916. Since that time he has been engaged in consulting and commercial enterprises.

During the war he was assigned to the Chemical Warfare Service in charge of construction of gas plants in the United States and after the armistice was with the Construction Division of the Army, returning to Chicago in 1920 where he was assigned to the staff of Gen. Leonard Wood, in charge of maintenance and operation. He was chief engineer for A. M. Castle & Co. and vice president of the Valentine-Clark company.

Col. Ellicott brings the Board of Education a sound training in engineering and economics, which will help him to meet the many vexing problems that will come before him for attention. His friends in the Society extend every wish for a successful administration of his office.

Nominated President A. S. M. E.

W. L. Abbott, Past Pres., W. S. E. Chief Operating Engineer, Commonwealth Edison Co. was nominated for President of the American Society of Mechanical Engineers at the spring meeting of that Society held in Milwaukee. There is little reason to doubt but what Mr. Abbott will be elected and if so he will be the second president of the American Society of Mechanical Engineers from Chicago. The election will close Sept. 22, 1925.

Mr. Abbott was President of the Western Society of Engineers in 1907.

APPLICATIONS FOR MEMBERSHIP

Members of the Society can be of great service if they will make a practice of examining the list of applicants published herewith and promptly notifying the Membership Committee or the Secretary regarding the qualification of any of those whose names appear on the list. The Society desires to extend its membership and receive those engineers who have the proper qualifications and wish to participate in its activities. The following applications have been received since last report:

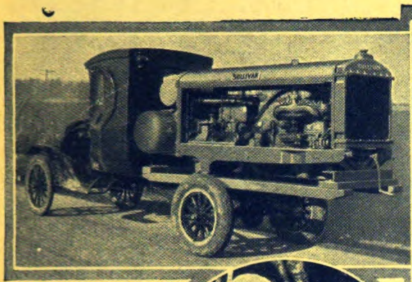
No.	Name	Address
62—1925	Jacob Souderegger	1457 E. 69th Pl., Chicago, Ill
63	Samuel E. Berkenblit	3214 Hirsch St., Chicago, Ill.
64	Edwin Schwarz	3333 S. Michigan Ave., Chicago, Ill.
65	James A. Davidson	4626 N. Hermitage, Chicago, Ill.
66	John H. Parsons	506 S. Darling St., Angola, Ind.
67	Curtiss J. Peterson	400 S. College St., Angola, Ind.
68	Paul A. Millis	713 W. Prospect, Angola, Ind.
69	A. J. Bain	1023 Addison St., Chicago, Ill.
70	Frank A. Coy	1629 Wilson Ave., Chicago, Ill.
71	Christen Christensen	710 W. Madison St., Chicago, Ill.
72	Ray M. Ring	2131 S. Michigan Ave. Chicago, Ill.
73	Thomas Blair	156 E. Pearson St., Chicago, Ill.
74	Edward T. Riley (Transfer)	45½ E. Walton Pl., Chicago, Ill.
75	D. J. Underwood	520 Old Colony Bldg., Chicago, Ill.
76	Ray M. Schmitter	2339 So. 50th Ave., Cicero, Ill.

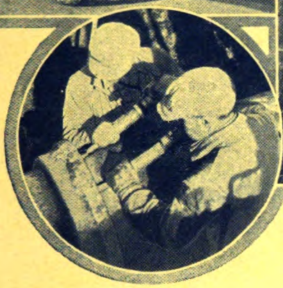
77	Melville H. Larson	2141 Sherman Ave., Chicago, Ill.
78	Arthur H. Allyn	4844 Winthrop Ave., Chicago, Ill.
79	Charles A. Wickstrom	137 Woodland Ave., Western Springs, Ill.
80	C. Winslow Hankle	5309 Greenwood Ave., Chicago, Ill.
81	E. J. Williams	311 E. Gilmore St., Angola, Ind.
82	Alphonse L. Kech (Transfer)	7006 S. Elizabeth St., Chicago, Ill.
83	Harold H. Cates	847 Monadnock Block, Chicago, Ill.
84	James Hugh Moylan	1727 Wabash Ave., Flat C., Chicago, Ill.
85	John Humphries	413 So. College St., Angola, Ind.
86	James M. Kennedy	122 Arlington St., Winnipeg, Manitoba, Can.
87	Jesse H. Grant	Transcono, Manitoba, Canada.
88	Arthur N. Gustafson	4141 Clarendon Ave., Chicago, Ill.

NEW MEMBERS

The following were elected to membership in the grade shown by the Board of Direction, April 20, 1925.

No.	Name	Address	Grade
299—1924	Lionel Benjamin (Transfer)	7234 Indiana Ave., Chicago, Ill.	Junior
454	Leslie W. Bartow	1400 E. 53rd St., Chicago, Ill.	Junior
8—1925	Walter F. Glauser	162 W. 74th St., Chicago, Ill.	Assoc.
13	Robt. M. Barnes	310 Gary Ave., Wheaton, Ill.	Affil.
29—1925	Wm. C. Stammer	415 S. Darling St., Angola, Ind.	Student
30	J. Kenneth Mayer (Transfer)	Box 555, Belmar, N. J.	Junior
31	Alva B. Simons	Northwestern University, Evanston, Ill.	Junior
32	George R. Culley	135 E. 11th Pl. Rm. 706, Chicago, Ill.	Assoc.
33	Harry Kraft	151 W. Maple Ave., Downers Grove, Ill.	Member
34	Edward J. Jaros	1244 N. Central Ave., Chicago, Ill.	Student
35	Andrew F. Marsch	12127 Eggleston Ave., Chicago, Ill.	Assoc.
36	Frank J. Kornacker	2000 Addison St., Chicago, Ill.	Student
37	M. M. Newlander (Transfer)	123 Pratt Block, Kalamazoo, Mich.	Member
38	James E. Mackay	224 E. Huron St., Chicago, Ill.	Junior
39	Robert E. Hattis	4152 N. Mozart St., Chicago, Ill.	Assoc.
40	John Lazdauskis	6044 S. Peoria St., Chicago, Ill.	Junior
41	R. Roy Dunn	Y. M. C. A., Gary, Ind.	Affil.
42	Harry C. Peterson	1915 Balmoral Ave., Chicago, Ill.	Junior
43	Fred Farrell	2420 Noyes St., Evanston, Ill.	Member
44	Carl F. Lorimer	628 Eauclair Ave., Columbus, Ohio	Junior
45	F. Raymond Nelle (Transfer)	3222 Michigan Ave., Chicago, Ill.	Junior
46	Arthur G. Dixon	5518 W. Ohio St., Chicago, Ill.	Junior
48	Chas. A. Nagel	Downers Grove, Ill.	Assoc.
49	Mortimer J. Frankel	1512 Hyde Park Blvd., Chicago, Ill.	Member
50	Henry Irwin	6807 Indiana Ave., Chicago, Ill.	Junior
51	Edward J. Hughes	810 Otis Bldg., Chicago, Ill.	Assoc.
52	Charles S. Riche	Boatmen's Bank Bldg., St. Louis, Mo.	Member
53	George W. Lyons	1400 E. 53rd St., Rm. 430, Chicago	Junior
54	Bahig Hassan	1410 Wrightwood Ave., Chicago, Ill.	Assoc.
55	Fred K. North	1801 Diversey Parkway, Chicago, Ill.	Member
56	Paul A. Nemoede	2734 N. Sacramento Ave., Chicago	Student
57	James E. Farnsworth	3902 N. Kenneth Ave., Chicago	Student
58	A. R. Lepin	508 So. Lawndale Ave., Chicago, Ill.	Assoc.
59	Mariano Moreno	C. R. I. & P. Ry., La Salle St. Sta	Member
60	Allen C. Stephens	6 N. Michigan Ave., Chicago, Ill.	Member
61	Lester M. Marx (Transfer)	1535 E. 61st St., Chicago, Ill.	Junior





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Sullivan gasoline engine driven portable compressors come in 3 sizes, 110, 170 and 220 cu. ft., with steel wheels or trailer truck (rubber tires) or skid mountings. There's a Fordson-operated 120-ft. unit and 4 sizes of electric driven portables, 120 to 258 cu. ft.

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JOURNAL of the WESTERN SOCIETY of ENGINEERS

PUBLISHED MONTHLY

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In this issue:

Vol. XXX No. 6

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JOURNAL OF THE
WESTERN SOCIETY OF ENGINEERS

Volume XXX JUNE, 1925 Number 6

The Annual Meeting

THE Fifty-fifth year of the Society's history came to a fitting climax at the Annual Meeting and Dinner, held Wednesday, June 3 in the Hotel La Salle. Over 160 members and guests sat down to dinner in the Red Room shortly after 6:30. The dinner was excellent and was enlivened by music furnished by a first-class, five-piece orchestra. Immediately after dinner, President Howson called the meeting to order and introduced William Longstreet of the Peoples Gas Light & Coke Co. who rendered two vocal selections which were well received.

President Howson's address which is here reported in full gives a concise review of the progress of the Society during the past year and its present condition, which is most encouraging.

President Howson's Address

"THE Western Society of Engineers is unique among engineering societies if not among societies of similar purposes in any of the professions in the continuity of its history. Organized in 1869 as the Civil Engineers' Club of the Northwest it is tonight completing the 55th year of its history. Only two other engineering societies now in existence ante-date it. It may be of interest in this connection to recall the part which one man played in the organization of the Western Society of Engineers and in the two other societies which were organized prior to ours.

"As a young man engaged in municipal work in Boston, E. S. Chesbrough became imbued with the idea that engineers had much to gain by associating together. As a result he took the initiative in the formation, in 1848 of what is now the Boston Society of Civil Engineers, the oldest technical engineering association in North America. Moving to New York a few years later he advocated the creation of a similar organization there, and as a result the American Society of Civil Engineers came into being in 1852. In the meantime the village near the lower end of Lake Michigan was rapidly developing into a city, and Mr. Chesbrough came west and laid out the sewer system which still serves the downtown loop area to this day. He brought west with him his ideals of engineering organization and the Western Society of Engineers came into being.

"From this beginning has grown the society with which we are familiar.

"Throughout its career or more than half a century the Western Society of Engineers has adhered strictly to the principles that it is a local rather than a national society, and that its function is the intensive cultivation of the professsional life of Chicago and its suburbs. So successfully has this been done that no less an authority on engineering societies than Calvin W. Rice, secretary of the American Society of Mechanical Engineers, stated in Chicago within the last two weeks that it has been his observation that the engineering world looks on the Western Society of Engineers as an organization ranking with the national societies in professional standing and influence. This is the heritage that has been built for us by those who have guided the organization through the years that have passed.

"When you placed on me and my associates the responsibility for the affairs of the society a year ago we felt somewhat like the young man who came around the football field for the first practice with the comment to the coach that "I am a little stiff from bowling", to which the coach replied: "I don't care where you're from. Get out on the field." In like manner we understood that you, the members of the Western Society of Engineers, were not interested in our previous history but that you wanted results. At the annual meeting a year ago we pledged to you that we would endeavor to measure up to the trust which you placed in us. I desire, there-

fore, at this time to make a brief report of our stewardship in order that you may know of the progress which the society has made during the year, and weigh carefully the work which has been done.

Membership

"At the end of the last fiscal year on May 31, 1924, the membership of the society was 2,334. During the current year 346 members have been added, while 16 have died, 71 have resigned and 113 have been dropped for non-payment of dues, leaving the net increase of 144 and the present membership of 2,478. I desire particularly to report to you the activity of the Board of Direction during the past year in dealing with delinquent members, a problem confronting all organizations. Of late years, and particularly during the past year, the society has been very diligent in clearing up its membership records with the result that there are today no members in arrears for dues prior to the year just closed and less than 5 per cent in arrears for this year. So far as I can ascertain this condition is unique among various organizations of similar characteristics and size.

"Your officers desire to express their appreciation to the membership for this support and also to solicit the co-operation of those members who allow their dues to remain unpaid until late in the year, for if all dues were paid promptly at the beginning of the year the society would be able to divert the time of employees and the expenditure of more than a thousand dollars to more constructive service for the society.

"A word about our finances may also be of interest. Our society in common with all engineering societies suffered severely during the war. Many of our members were in service and their dues were remitted, reducing our income at a time when all expenses were mounting. As a result, in spite of the most economical administration the resources of the society were severely taxed until at one time we had pledged our securities of the society as collateral for loans aggregating $9,900. In recent years these loans have been reduced until a year ago the amount overdrawn had been decreased to $2,409. During the past year, I am pleased to report, that this amount has been still further reduced to $885. The society has securities in its treasury of a par value of $13,000 in addition to $4,000 of trust fund endowments for awards. The society may, therefore, be said to have practically recovered from its wartime financial problem with resources unimpaired and without having put into effect any increase in dues.

Technical Activities

"One of the major objects of the society, as stated in its constitution, is the reading and discussion of papers on topics of engineering interest. That this has been well done during the current year under the supervision of our program committee is indicated by the fact that 38 meetings were held, attended by 6,717, the largest number ever attending our technical meetings in any year, and exceeding the attendance of 5 years ago by more than 30 per cent. It is also interesting to note that the average number attending the meetings was 177, or 97 per cent, of the permanent seating capacity of our auditorium. The programs were of an unusually high order, including the presentation of papers on such subjects as the mercury vapor turbine, the Tribune Tower, the transmission of photographs by wire, the Illinois Central terminal improvements and the Dix River Hydro-Electric project.

"Closely related to our technical program was the 4th Midwinter Convocation which was held in the rooms of the society in February. Twelve papers were presented at this Convocation having to do with the progress of Chicago and the engineering problems growing therefrom. These papers were published in the April Journal of the society and have attracted very favorable comment from lay as well as engineering leaders of our city.

"In addition to its technical activities the society held 6 noon day luncheons attended by 774, 6 excursions to points of interest attended by 567, 4 social evenings with an attendance of 488, and other meetings of the Young Men's Forum, etc., bringing the total attendance at the various activities of the society to more than 10,000.

Library

"Second only to the technical programs in point of value to the profession is the

library service rendered by the society. This has taken on greatly increased importance during the last few years and is being more generally used by our members as the character of the service offered is improving. We have a library of more than 9,000 volumes of engineering literature to which approximately 600 volumes have been added during the year, including a gift of 450 volumes of structural engineering books from the late H. C. Lotholtz, and numerous gifts from other members. The cataloging of our library which has long been sorely needed has proceeded continuously during the past year, and is now 80 per cent complete with the prospect that it will be entirely finished in September. As an index of the service afforded by the library our librarian has been called on to answer more than 3,000 inquiries during the past year, including such diversified topics as the number of Diesel engines in the United States and the purposes for which they are employed, the number and location of the reinforced concrete docks built in Europe before 1907, the amount of wear on sleeve, ball and roller bearings due to the pull of belting when operated by electric drive, and the date that Andrew Carnegie placed the first order for a steel freight car.

"Our society is now spending $5,000.00, or 12 per cent, of its income for library service. The increasing use which our members and others are making of the library indicates its value. It is apparent, however, that the service can be made still more valuable by the expenditure of more funds for books and for assistance. At the same time it is doubtful if the society is warranted in spending a larger proportion of its revenue for this one service. Rather, it would seem possible to finance this additional service by the subscriptions from those industries and firms which have occasion to use the library service frequently. The experience of those commercial organizations which attempt to maintain libraries for their individual use is that such service becomes highly expensive. In its place it would appear practical for such companies to merge their libraries with that of the Western Society of Engineers, looking to the society for such service as they require and compensating it by an annual subscription, thereby reducing their cost and at the same time increasing the size of the library which would be at their call.

Alvord Gift

"An outstanding development of the society during the last year was the receipt of a gift from Past President, John W. Alvord, of $2,000 as additional endowment for the Washington Award, established originally by him in 1916. This is the largest gift ever received by the society during the more than half a century of its existence and the income from this gift will be employed in accordance with the wishes of the donor in recognizing engineers who have contributed to the happiness, comfort and well-being of humanity.

Co-Operation With Other Societies

"The Western Society of Engineers has long been committed to the principle of co-operation with other engineering societies to the end that overlapping activities may be eliminated and the profession unified. During the last year this co-operation has been increased in several ways. Most important is the perfection of an arrangement with the four national societies for a joint employment service. The Western Society of Engineers has maintained a free employment service on a modest scale for several years. It has been evident, however, that a more extensive service would be of greater value. The four national societies established such a service at their headquarters in New York three or four years ago. Arrangements have been completed within the last two weeks for the substitution for our free employment service of an enlarged service to be operated jointly with the four national societies and to be supported by contributions from those served, offering a more extended service to employer and employee.

"Allied somewhat closely with this has been the proposal by our society that it perform the secretarial service for the local sections of the national engineering societies on a cost basis, which proposal has been accepted definitely by one of the national societies and tentatively by two more.

"The engineering building which has long been under discussion has again

taken on new life during the year and a committee has been appointed jointly by the Western Society of Engineers and the Chicago Engineers' Club which, under the leadership of James O. Heyworth, chairman, is giving active consideration to the feasibility of an engineering building and the development of the details of a definite project. It is probable that the next year will see developments in this direction. In the meantime, arrangements have been made for the consolidation and re-arrangement of the offices of the society which will be accomplished during the summer so that with the beginning of activities in the fall a more compact and convenient arrangement will be in effect.

"The society has continued to take an active interest in those problems of a public character which depend directly or indirectly upon engineering principles for their solution. That this interest has been recognized and is of value is indicated by the many opportunities which have been offered the society for service and the credit and appreciation which have been given freely by the Mayor of the City of Chicago and other public authorities. Never before has the society received more recognition and appreciation for its work in this direction than during the present year.

Our Publications

"Our Journal has continued to command the interest of our members to an increasing extent, justifying the action which was taken two or three years ago in changing the character of our publication so that while losing none of its technical value it would incorporate more of the news of the society.

"I wish that time permitted me to make reference to the splendid work done by our standing and special committees during the past year. This is not possible, however, and I can only express the appreciation of the Board of Direction to the large number of men who have given freely of their time and energy to the interest of the engineering profession and the public at large. I cannot close, however, without a word of appreciation to my associates on the Board of Direction for the loyal co-operation which they have extended to me throughout the year. They have given freely of their time to the direction of the work of the society and the credit for such progress as may have been made during the past year is due to them. Particularly do I desire to thank our secretary, Mr. Nethercut, and his associates, Mr. Mercer, Miss Hoierman, Miss Krieg, Mr. Rabbe and the other members of our staff. It is to these persons who devote their entire time to our society that its success depends in large measure."

New President Presented

In closing, President Howson announced the names of those officers chosen to manage the Society's affairs for the next year and asked each to rise when his name was called. He reserved President-Elect, Homer E. Niesz, for the last and in introducing him added a personal word of genuine appreciation of the excellent service which he has given in his years on the Board of Direction of the society. He presented Mr. Niesz with a President's badge in accordance with a custom which was established a few years ago. Mr. Niesz's response was brief and expressed the hope that the coming year will see a continuation of the excellent progress that has been evident in years past. He said:

"I AM deeply impressed by the great honor conferred upon me by election to the office of President of this unique and wonderful society of ours—unique because it is in a class all by itself as a local all-embracing engineering organization, and wonderful because it includes in its membership so many of the most noted and illustrious engineers of the great middle west—leaders of the engineering world.

"The honor conferred carries with it an obligation of great weight and potency and I wish to say on behalf of my silent fellow officers and directors that we appreciate the extent of the obligations we are assuming and pledge our most ardent devotion to the duties and the opportunities before us, in the hope and determination that our administration shall maintain the high and ever higher standard set for this society each succeeding year.

"We have heard from the eloquent lips

of our, so to speak, retiring President the stirring recital of his accomplishments and it is a brave man indeed who will attempt to compete with or mayhap to excel, him either in work or in words.

"It appears to me as rather significant that so many of the Past Presidents of this Society have been particularly noted for their forensic abilities—more nimble with the tongue than with the slide-rule, more prone to juggle rhetoric than to solve abstruse mathematical problems. I would not presume to reflect in any way on the high standing in engineering of my distinguished predecessors, who have served with such credit and honor to the Society and to themselves. To them I bow with greatest respect and highest esteem. Every body should have a head which should serve as its mouthpiece and tell the world of its accomplishments, and it is this highly desirable faculty of our past presidents to which I have referred and for which services to the Society they deserve our grateful thanks.

"Generally speaking, engineers are reticent as to their abilities; hesitant in publicly expressing their ideas and accomplishments and wary of the glare of publicity. They need, individually and collectively, an organization which can give voice to their work and spread so all can hear or read the story of engineering achievements which are so many and so varied and so valuable to all mankind.

"Such an organization is our Western Society of Engineers and one of its important duties to its members is to give proper publicity to their valuable contributions to engineering development. The Society is to be congratulated on its splendid membership, including all of the grades of every branch of engineering; on its facilities and advantages available to its members, including the best *technical library* devoted exclusively to engineering in Chicago; on its standing as a local authority whose opinions are held in high esteem by the community; on its splendid cooperation with the national technical societies as evidenced by joint meetings held during past years, the joint employment service just entered into, the proposed joint secretarial service now under negotiation and in other ways; on its many working committees whose members give uncounted hours of time and thought for the benefit of the profession; on its Board of Direction which has the responsibilities of managing and directing its affairs; and on its Secretary and efficient staff who handle all the details of operation and keep the intricate machinery of the organization running smoothly. All these are essential elements of a successful society.

"Let us then all work together to build up our society, add to its membership, increase our service, improve our meetings, effect closer cooperation with other engineering and civic organizations, bring to realization the dream of years—an Engineering building, all to the end that our Society shall do its full share in promoting and advancing the engineering profession."

After Mr. Niesz had spoken, President Howson called upon George Simpson, one of the men associated with Mr. Cauley in the Peoples Gas Light & Coke Co. who entertained with a few clever whistling numbers. He has been heard frequently over several of the radio broadcasting stations in Chicago. His bird imitations were very good and well received.

Washington Award Presented

Next in order came Dabney H. Maury, M. W. S. E. who was asked to make the formal presentation of the Washington Award in the absence of W. L. Abbott, Chairman of the Washington Award Commission, who was ill. Col. Maury made a very fitting presentation speech which recounted briefly some of the reasons why the Commission had chosen Jonas Waldo Smith. His presentation of the Award was as follows:

"THE absence of W. L. Abbott, Chairman of the Washington Award Commission, is greatly to be regretted. The wisdom, tact and courtesy which he has displayed as presiding officer at the meetings of the Commission would have endeared him to every one of its members had they not already loved him for these and the many other admirable qualities which they knew him to possess. The fact that he is prevented by sickness from being present here tonight and from exercising

his privilege to make the presentation of the Washington Award, will be deplored by every one of you, and in that feeling I sincerely share.

"The inscription on the Washington Award states that it is conferred in the year 1925 upon Jonas Waldo Smith for pre-eminent services in promoting the public welfare and for the rare combination of vision, technical skill, administrative ability and courageous leadership in engineering. This language so aptly describes the attributes and deeds of the recipient that it will be the text of what you will hear from me this evening.

Early Education

"A brief outline of the life of our distinguished guest would read as follows:

"Jonas Waldo Smith was born on March 9, 1861, at Lincoln, a small town near Boston. Here he spent his boyhood and attended the public schools. At nineteen he went to Phillips Academy, Andover, where he graduated in the scientific course in 1881.

"Before going to this school, however, and while he was still only a boy, he took part in the construction of the local water works system, which was naturally a small plant, having only about four miles of water mains and a pumping station of proportionate size. After the completion of this plant, he, for a time, operated it, and in the broadest possible sense of the word, for he acted in the triple capacity of Fireman, Engineer and Superintendent.

"After graduating at Phillips Academy, there followed two years of hydraulic engineering work at Lawrence, and four years study of engineering at Massachusetts Institute of Technology, where he graduated in 1887.

"During his college vacations, and for some three years thereafter, he gained much valuable experience in the testing of turbines and in the making of noteworthy hydraulic experiments for the Holyoke Water Power Company.

"His next engagement was with the East Jersey Water Company, first as Resident Engineer, and then as Principal Assistant Engineer.

"In 1897 he was made Engineer and Superintendent of the Passaic Water Company, and other affiliated Companies, supplying many communities in North Jersey; and a few years later was made Chief Engineer of the East Jersey Water Company.

"He also served as Consulting Engineer on the design and construction of the Boonton Reservoir, and of the long pipe line supplying water by gravity to Jersey City.

"In 1903 he was made Chief Engineer for the Croton Aqueduct Commission.

"From his boyhood on he had worked with unfailing energy, and as his experience breadened, with ever increasing ability and skill. Every change in his occupation was a well earned promotion "Per aspera ad astra"—"Through the rough places to the Stars."

Appointed Chief Engineer

"His record on the Croton project led to his appointment in the summer of 1905 as Chief Engineer of the largest and most important water works the world has ever seen, the additional supply for the City of New York from the Catskill Mountains. This project involved an expenditure up to 1917 of about $175,000,000 for work which was performed on schedule time and at a cost of about $9,000.000 less than the original estimate. The details of this enormous enterprise, with its huge reservoirs, its long conduits, its tunnel under the Hudson River, nearly 1200 feet below sea level; and countless other features of corresponding magnitude, requiring the maximum of skill in design and construction, have been so often described that they need not be repeated here. Suffice it to say that every part of the work was designed and carried out swiftly, skilfully, economically and cleanly, and has stood the acid tests of time and service.

"In the execution of this work, Mr. Smith gathered ground him a technical staff of exceptional ability. His engineering organization at times exceeded a thousand men, all imbued with a remarkable *esprit de corps* and admiration for their leader. Their loyalty to him was sincere and affectionate, and every one of them today takes the greatest pride in the fact that he was privileged to work under Mr. Smith on this great project.

"In 1922 Mr. Smith was appointed Consulting Engineer for the New York Board of Water Supply.

"In 1918 he was awarded the John Fritz Medal for achievement as Engineer in providing the City of New York with a supply of water.

"Mr. Smith has been a member of the American Society of Civil Engineers since 1892, and served as Director of that Society from 1906 to 1908, and as Vice President in 1913 and 1914. In 1918, Stevens Institute of Technology conferred upon him the honorary degree of Doctor of Engineering; and Columbia University, the honorary degree of Doctor of Science.

As a Leader

"This brief summary of his career gives but the bare bones of his achievements. It tells little of the personality of the man. If some eloquent speaker, some man having the gift of tongues, could be assigned the task of weaving into the web of the fabric just set up, something of Mr. Smith's shrewdness and sagacity, his wisdom and his vision, his diplomacy and his daring, his honesty and his earnestness, his kindness and his unfailing courtesy, then we should have a story that would be an epic.

"The inscription on the Washington Award cites his pre-eminent services in promoting the public welfare. From his boyhood down to the present day, all of this man's services have been of just that character. He has never been engaged in commercial enterprises nor been interested in the acquirement of large financial rewards, which might well have come to him had his energy and skill been devoted to those lines of endeavor.

"Again reading from the inscription we find the words, 'For the rare combination of vision, technical skill, administrative ability and courageous leadership in engineering.' These qualities are all attested by the list of his achievements,—but the list does not tell the whole story.

"The part of the inscription which I like best is the phrase 'Courageous leadership in engineering.' Courage means much. First of all, it means unselfishness and devotion. Engineers are as a class unselfish. Shortly after the belated entry of our country into the World War, five men pre-eminent in the engineering profession, who constituted a Committee charged with forming an organization for emergency construction, selected 300 Engineers from all over the United States, and sent to each of them a telegram reading about as follows:

> "'Will you give some time to the service of the United States Government no appropriation for services or expenses though one may be had later.'

"I saw the list and the answers. There were 299 "Yes's" and one "No." What other profession would have given a response so nearly unanimous to a question which gave no assurance of anything except the opportunity for unselfish and unrewarded service?

Courage in Engineering

"There are several kinds of courage. Speaking from an engineering standpoint, there is daring in design or construction. This is like the courage that Davy Crockett had, 'Be sure you are right, then go ahead.' One of the finest instances of this daring is the Little Falls Filtration Plant, built by Mr. Smith. This was the first notable use of reinforced concrete for structures intended to contain water and to sustain heavy loads. The walls and floors of this filtration plant were so thin that Engineers all over the country looked at the drawings with amazement; but Mr. Smith was sure that he was right, and he went ahead.

"When the elephant has tested a bridge, then the smaller fry of the menagerie can cross it unafraid and in safety; and we other water works engineers throughout the world have been copying the essential features of the Little Falls Filtration Plant ever since its successful completion.

"The great tunnel nearly 1200 feet under the waters of the Hudson, is another instance of supreme engineering daring. The Cornish miner says, "You can't see ahead of the point of your pick," but Smith devised a very long pick in order to learn what his tunnel would have to encounter. The tunnel had to be so deep that it would have been utterly impossible to construct it by any pneumatic process. It was therefore necessary to determine in advance the nature of the rock that would be pierced by the

tunnel, and whether this rock carried seams or fissures which would admit to the tunnel more water than could be handled by pumps. A shaft 200 feet deep was sunk on each side of the river, and from these shafts, drill holes 2000 feet in length were sent down on an angle until they passed each other under the bottom of the river. An account of the drilling of these holes, and of the ingenious method by which the inclination of the boring was at all times made known to the Engineers, is of itself a story of absorbing interest. It is enough to say here that these borings showed that there were no dangerous fissures, and Smith, having made sure that he was right, went ahead and completed the tunnel.

Kinds of Courage

"Another kind of courage is the moral courage of the man who is brave enough to risk his reputation to do the thing which he knows to be right. When the bids for the great Ashokan Dam were opened, the lowest bid was $2,000,000 less than the next lowest. Smith knew that the lowest bidder could not do the work as well as the next lowest, and he braved the storm of criticism that was directed at him, and awarded the contract to the next lowest bidder. Smith was in the end so triumphantly vindicated that his action in this matter is now universally looked upon as one of the high spots in his exceptionally honorable career.

"Then there is the courage that makes a man ready to sacrifice his life, if need be, for a cause, or for his fellow men. The opportunity for such sacrifice does not often arise, but when such an opportunity comes to an Engineer, he almost invariably meets it squarely.

"Nearly 40 years ago, John Meem, then barely twenty-one years of age, and just graduated from the Virginia Military Institute, was engineer for a coal mine in West Virginia. An accident happened and the mine was flooded. In those days there were no gas masks and none of the mine rescue appliances that are now universally required. Young Meem knew that many men were caught in the mine, and he thought he knew the place to which they would naturally go as the water rose. Against the protests of all around him, he went down the shaft alone. He found the tunnel leading to the place of refuge almost filled with water and pushed his way through the flood, at times having to swim and at times through places where the roof was so low that there was scarcely room for his head between it and the surface of the water. He traveled thus for a third of a mile in the darkness, found thirty-nine survivors at the place where he expected to find them, and brought them every one to safety.

"In 1915 the Belmont tunnels under East River were being constructed through ground that presented many difficult and dangerous problems. Sometimes all of the 18-foot shell was being extended through rock, sometimes partly through rock and partly through river silt, and sometimes entirely through river silt. This silt was light, and at places very thin above the roof.

"In addition to the air locks at the principal shafts, another air lock was maintained in the tunnel itself, not very far back of the shield. On one occasion the covering of silt became so thin that it was blown off by the air pressure. St. John Clark, the Chief Engineer, broke away from those who tried to restrain him, entered the tunnel air lock alone, and closed the door behind him. He locked himself through,—to face he knew not what,—and found to his intense delight that the water had not yet risen quite high enough to drown the eleven men who were imprisoned between the lock and the shield. He brought into the lock as many of these men as could be accommodated at one time, and stayed in the lock himself until he had brought them all through to life and safety and God's daylight.

"On the left bank of the Passaic River, just below the Great Falls, there is a shelf of rock on which stands a pumping station which some fifteen years ago furnished most of the water for the communities supplied by the Companies for which Mr. Smith was then Chief Engineer. An unprecendented flood occurred and Smith knew that the waters of the river would rise much higher than ever before, and would surround the pumping station. Accompanied by the pumping station engineers, he entered the station,

taking provisions sufficient to last for a week, and hastily prepared stop boards to be placed across the windows in case the water should rise above their sills. The station is a long one-story brick building with high and wide windows along the sides. The pilasters between the windows are narrow and the sills of the windows are low. The water rose until it stood more than six feet above the floor of the station. From an examination of the walls, I believe that the only thing that kept them from being forced in by the pressure was the fact that the columns supporting the traveling crane were imbedded in the pilasters. The leakage passing the stop boards was heavy, but fortunately not too great to be handled by the sump pumps in the station. Smith and his engineers stayed in that building for three days and nights, and they kept the water supply in the communities which it was Mr. Smith's duty to serve and to preserve.

"John Meem and St. John Clark were both schoolmates of mine, and both were from Virginia. The worthy winner of our Washington Award is from Massachusetts. This ought to show that among Engineers, valor in the line of duty knows no geographical limitations, and Smith's life has shown beyond all question that he has every proper sort of courage, and that to paraphase MacBeth, 'He dares do all that may become a man. Who dares do more is none.'

"And now, Sir, on behalf of the Washington Award Commission, and for your pre-eminent services in promoting the public welfare and for the rare combination in you of wisdom, technical skill, administrative ability and courageous leadership in engineering, it is my privilege to present to you the Washington Award for the year 1925. With it I beg to tender my sincere personal congratulations and assurances of high esteem."

J. Waldo Smith Responds

IN accepting the Washington Award, Mr. Smith made the statement that it was the most satisfactory award that has come to him for the reason that in the words of the donor, it was an honor conferred by engineers on a brother engineer. Quoting further from the rules of the Washington Award he noted that the intent is that the award shall be conferred on account of accomplishments which preeminently promote the happiness, comfort and well-being of humanity. Mr. Smith said that he was particularly pleased with the word happiness, included in the conditions of the Award. Happiness, he said, was a state of mind to create an atmosphere of helpfulness.

In commenting upon some of the observations in his long career, he said that he was impressed by the character, ability and loyalty of his associates. He took occasion to make a special appeal for the young man in engineering and urged both young and old to realize the importance of the engineering profession and do all in their power to bring it into prominence.

One of the well known characteristics of Mr. Smith is his horror of jealousy, either in profssional contact or within working organizations. He maintains that instead of being jealous of the advancement of another engineer we should rejoice that a higher mark has been established for others to follow. He gave an example from his own career, when a difficult engineering commission was offered to him at an advance in salary. He was reluctant to accept the commission and the offer of salary was increased until he finally accepted. Within a year after this happened, the salaries of several chief engineers in the community were increased to still higher figures as a result of his own experience.

Mr. Smith commended the part that the Western Society is taking in the public affairs of Chicago and community and urged the example be followed by engineers in other localities.

One of the things that Mr. Smith mentioned especially was the importance of impressing upon executives the desirability of guiding the younger men in their organization by example and allowing them to show their power of self-determination, or in other words, allowing them to do things in their own way just so long as they got the correct results. He pointed out that the head of an organization may do a great deal to encourage or to stifle responsibility in his men. Since an engineer's principal joy

in life is to work to get things done, he should do everything in his power to cultivate responsibility.

Chanute Medals Presented

President Howson then called on Paul L. Battey and Walter A. Shaw, members of the Society, to come forward and receive the Chanute Medal given each of them in recognition of a paper presented before the Society during 1924. There were three medals awarded, the third being for the paper on the "Establishment of Isostasy" by John F. Hayford, former Director of the College of Engineering, Northwestern University, who died last spring. Dean Hayford's son, Maxwell, was present to receive the medal for the family. Presentation of these medals met a most enthusiastic response from the members present.

Judge Wilkerson Speaks

Hon. James H. Wilkerson, U. S. District Judge of Chicago, was the principle speaker of the evening. He chose to speak on the civic responsibility of the professional man. In introducing the subject he said that he was going to take the liberty of assuming that all members present were conscious of the profound responsibility which rests upon educated men to make some contribution to the welfare of the general public. In attempting to analyze this subject, he said that at once there occurred to him two elements which were fundamental.

The first thing to which he called attention was the responsibility placed on educated men in protecting our system of constitutional government against assault. The institutions of our government are not mere creations of some individual but rather are an outgrowth of situations which they were designed to meet. The founders of our government faced a critical situation with a number of independent states, each speaking liberty from an oppressive form of government and each determined to secure its individual rights. These must be united into a nation with full protection to the rights of all. As a result a form of government was designed, having three branches. It is natural that this should give rise to some conflict as the powers of each branch of government are not clearly defined. However that may be, the plan was followed without challenge, for more than a century with the Judicial department acting as a sort of balance wheel between the other departments.

Judge Wilkerson stated that we are at present passing through the third period of trial of our form of government. This is characterized by the drift toward nationalization of industries and the destruction of individual liberty, substituting therefor the domination of the State. An example of this is the government ownership and operation of railroads. Our Constitution provides that private property cannot be taken by the government without the owner being paid in full for it.

Another alarming element at present is the growing attitude of the agricultural population indicating that they are ready to give up their constitutional guarantees in return for some kind of government regulation which will insure to them what they think will be more rights and liberty. They forget that the Constitution guarantees that the same rights must be given to all. Many of these doctrines that are being advocated by certain elements are certain to lead to conflicts and ultimate destruction.

The second element which the Judge called attention to was the popular cry now being heard for enforcement of the law. We are constantly confronted with comparisons of crime statistics as between this country and European nations for the purpose of presenting a black picture of the lack of law enforcement. In considering this matter it is pertinent to inquire what is the responsibility of the educated man in regard to the enforcement of law.

It is rightfully said that there are too many laws, or that the fault is in the machinery of the courts, or in some other department of government. In such a situation as this, what is the real question at issue?

There have been numerous so-called progressive measures, advocated from time to time, but most of these have proved to be reactionary to a large degree; there have been proposals to change the form of government, which would simply be a return to the rule of des-

potism. In saying that the law must be enforced, it must be remembered that the chief end of law and law enforcement is the protection of the individual and the maintenance of equal rights for all.

The statement is sometimes made that there are too many laws. It is recognized that there are many laws which are inadequate, or out of date, as most of them were placed on the statute books by departments of the government which have nothing whatever to do with their enforcement. The Society of today is not that of our forefathers and there are many who fail to recognize this change. For example, Judge Wilkerson said that no man who is familiar with the railroad situation would think of repealing the laws which require the railroads to install and maintain adequate safety devices. He ventured the assertion that if it had not been for the Volstead Law, we would not hear any of this talk about there being too many laws, and that the various Bar Associations are doing good work in clearing up the situation.

Before there can be any real law enforcement, there must be behind it a public sentiment that respects law and demands real enforcement. Forty years ago it was a common thing for powerful men to defy the government. The effect of this has been to create a popular impression that the governmnt can be easily defied. This is a great hindrance to the real enforcement of the laws. Another example that is frequently cited is that because the Fourteenth and Fifteenth Amendments to the Constitution were repealed in several states the Eighteenth could be repealed just as easily.

Concerted action of honest thinking men is the most important thing to be sought in attempting to reach the solution of this situation. Without such action it is futile to think of establishing respect for law or of protecting the government against insidious assaults.

A. J. Hammond, M. W. S. E., has been nominated Director of the American Society of Civil Engineers from this district. The election is now in progress. Mr. Hammond has always taken an active interest in the affairs of both the Western Society and the American Society of Civil Engineers.

Reports on Free Engineering

As reported in the April Journal a special committee appointed by the Board of Direction to consider certain statements made regarding the alleged practices of manufacturers and distributors of equipment in giving free engineering service, submitted its report to the Board of Direction which approved it. The report was also submitted to the Directors of the Chicago Section, American Institute of Architects and the Illinois Society of Architects, both of which organizations have approved the report.

The following is the full report as approved by the three organizations:

Report of Committee on "Free Engineering Services"

Board of Directors,
Western Society of Engineers,
53 W. Jackson Blvd.,
Chicago, Ill.

Gentlemen:

This committee, to which the above subject has been assigned, reports as follows:

Certain complaints have been made to the Officers of the Society relating to certain practices by Engineers, Architects, Contractors and Manufacturers, under which it is claimed that injustice has been done to professional engineers and the public. The complaints allege that certain engineering services are rendered without specific remuneration therefor. The specific practices complained of may perhaps best be comprehended by a brief statement of the complaints as follows:

(1) A consulting engineer specializing in in water purification, complains that an agent for a company manufacturing and selling a chemical used in water purification, has tendered his services, in a certain instance, without remuneration, to the officers of a certain city, in furnishing plans and specifications for a water purification plant.

(2) A mechanical engineer objects to the practice of a manufacturing concern that manufactures and installs heating equipment under plans prepared by the manufacturing concern, without specific remuneration for the engineering work involved.

(3) An architect complains that a certain furniture manufacturer offers to make plans and specifications for building, providing that the manufacturer's

equipment is purchased. A similar complaint relates to manufacturers of jail equipment and vault equipment.

(4) A mechanical engineer complains that contractors for piping in buildings offer to prepare plans for such piping, with no specific remuneration therefor, except the prospect of being awarded the contract.

(5) An engineer complains of the practice of certain merchants selling reinforcing bars, who offer to design and detail reinforced concrete construction, in consideration of an order for the bars without specific remuneration for the engineering work involved.

(6) A structural engineer complains that certain contractors offer to build bridges upon their own designs, without specific remuneration for the engineering services.

(7) A contractor complains that certain building contractors offer to build buildings from their own architectural drawings, without specific remuneration for the architectural services.

In considering the above matters this committee has held several meetings. It has published a request in the Journal that complaints relating to this subject, should be offered to it, resulting in the receipt of several letters bearing upon the above subject. It has heard verbally several complaints, and it has questioned those who complained.

In the consideration of this matter, it should be noted that the Western Society of Engineers includes in its membership engineers and architects in general practice. It includes a large number of very capable engineers, employed by public and private corporations. It also includes engineers operating as contractors and manufacturers. All of these members may be more or less interested in this subject under consideration.

The Development of Specialties

This committee calls attention to the development of certain engineering specialties as having a bearing upon the matters which have been complained of above.

The steam pump was first largely used in this country, in water works' systems, about forty years ago. The first machines for this purpose were conceived, designed, built and installed by manufacturers thereof, who found it necessary also to design and build the pipe systems and appurtenant works necessary for the utilization of the pumps as there were no engineers in general practice familiar with the subject. Thus the practicability of steam pumps in general systems of municipal water works was demonstrated. In the course of time many technical men became expert in the application of pumping equipment, and the design of the appurtenances necessary for water supply. As knowledge upon this subject became more general, the manufacturer found plenty to do in the manufacture of his pumps and various other devices in the projects gravitated to certain other manufacturers. At the present time practically all the designs are made by consulting engineers, or by engineers and operating officers in the employ of municipalities and corporations, and the larger part of such equipment is purchased on plans and specifications.

The mechanical filter for the purification of water is an American invention, conceived, designed and demonstrated by an American manufacturer. When first placed upon the market its efficiency was discredited by sanitarians in general. The early installations were designed and built by the manufacturers who subcontracted the miscellaneous structures necessarily appurtenant thereto. In order to get business the manufacturer necessarily guaranteed the efficiency of the process to produce clear, pure water. In the course of time, ten to fifteen years, the value of the mechanical filter became generally recognized. Other manufacturers entered the field. Several bids on widely different bases were presented for each job. For a few years detailed designs were made by manufacturers under general specifications prepared by engineers for purchasers. As the process became generally known to engineers the art finally reached the stage where detailed designs were made by purchasers agents, the greater part of the construction was carried out by general building contractors and the work of the filter companies was limited to their special apparatus in the same way that the equipment of buildings is now generally sold.

Mechanical filtration, now serving water to 20 million people in the United States, saving thousands of lives annually, could have been developed in no other way.

Reinforced concrete in the past thirty years has gone through much the same process and development. At first only a very few knew how to design it. Builders were skeptical of it. Early structures were designed and built by those who conceived them, under some form of a guarantee. At present, knowledge as to design is widely disseminated among technical men. There remains some effort

on the part of steel merchants to assist in the design as an extra inducement to the purchaser. This tendency is rapidly disappearing. The evils resulting from the practice will be self curative with a wider distribution of knowledge.

Structural steel has had a similar history. Certain large contractors secure many large undertakings under a form of contract, in which design and construction are furnished. Such a contract, including both professional and commercial service, eliminates competition in construction and must be executed with most scrupulous care to protect the interests of the owner. The form of the remuneration varies somewhat.

A contract is unfair, and not in the interest of the Public, where a builder or others prepares a design and subsequently becomes a bidder in competition with other contractors under his own design. This practice should be discouraged. Under any circumstances, success in carrying out work in which the constructor designs, depends upon the ability and integrity of the contractor. Such work should be carried out under a form of contract, through which the contractor has every incentive to do good work with a proper regard for economy.

Conclusions

(1) Engineers, architects, manufacturers and contractors should cooperate, insofar as possible to eliminate objectionable practices, whereby unfair advantage is obtained on the part of one at the expense of the other, or where the buyer may be imposed upon.

It is perfectly evident that there is no such thing as free engineering. There must be a sufficient remuneration. It is in the interest of all that this remuneration should be fair and open. An exorbitant remuneration should not be concealed in the price of the article or device.

(2) It is recognized that new contributions to advancement in the useful arts must pass through a stage in which the designer builds and takes full responsibility. If the contribution is a real advancement, knowledge regarding it will ultimately be widely disseminated, after which it will be designed by purchaser's agents. With a widely expanding field, this is accepted as inevitable by the manufacturer. In many cases it is welcome. This condition comes about through evolution, it cannot be influenced to any large extent by rules and regulations on the part of practitioners.

(3) The business of manufacture and sale of machinery and complicated equipment cannot be conducted today without an engineering force, expert in the application of the equipment. No consulting engineer or architect should fail to advise himself regarding available equipment by consultation with the manufacturer's experts. There is no other way to apply correctly the best devices to the required service. However, no self respecting engineer or architect will secure from a manufacturer the design of a structure, or a part of it, under an implication that a purchase will be made from the manufacturer, and then turn over to the client the result of this work as his own. This is bad ethics and bad morals.

(4) This committee recommends no legislation and no rules on this subject. it is suggested that this report, or such part of it as may seem useful, be published in the Journal of the Society.

H. J. Burt, Chairman,
C. B. Burdick
W. J. Lynch
Linn White
R. G. Rosenbach
V. A. Matteson
J. T. Hanly.

Johns Hopkins to Award Assistantship in Gas Engineering

The School of Engineering of Johns Hopkins University will award a graduate assistantship in Gas Engineering for the academic year 1925-26. This assistantship will pay the holder $500. In return he will be required to spend a number of hours each week assisting in the undergraduate laboratory instruction in Gas and Fuel Technology.

Applicants for this assistantship must be candidates for advanced degrees in Gas Engineering, and the holder will be expected to pursue advanced instruction and research in this field.

Persons desiring to submit applications or secure further information, should address their applications to Wilbert J. Huff, Professor of Engineering, Johns Hopkins University, Baltimore, Md.

Appreciates W. S. E. Report

An editorial appearing in the *Engineering News Record* of June 11 comments upon the recent report of the Bridge & Structural Section, Executive Committee covering their studies in the tornado damaged area in southern Illinois, presented at our meeting on May 25. This is in reference to a six-page article appearing in that issue, describing the important points brought out in that report.

Such editorial comment is an indication of the value of this kind of study. Similar studies are being considered by other committees of the Society, which deal with subjects of equal importance to other branches of engineering. By conducting such investigations the Society can make a valuable contribution to the profession of engineering. One of the most important things to remember in this connection is, that the individual members who devote the time and effort, to making the investigations, are the ones who derive the most benefit therefrom.

The editorial mentioned above reads as follows:

Study of Tornado Effects

"The engineers who went down to southern Illinois to see the destruction done by the great March tornado and interpret its effects in structural terms have done a notable thing in rendering the report summarized in this issue. They have made a basic contribution to human safety and improvement of our constructions with respect to these tremendous storms. Their work is at best a fragment, being an interpretation of the difficultly legible record of a single tornado; nevertheless it is a pioneer contribution, that in time should lead to such an understanding of the powers of tornadoes as will enable men to escape from or protect against their destructive powers.

"Meteorologists have given close study to tornadoes for many years, yet their efforts do not seem to have been of much help in furthering protection of life and property. Where the meteorological observer is concerned with velocities, pressures and isotherms, the structural engineer on the other hand studies force and energy effects. And these in turn make direct contact with the problem of how strong to build.

"Strange and confusing happenings occurred in the tornado-swept region, as in other regions in other tornadoes. The observers have recorded many terrifying exhibitions of power. Their calculations indicate very large forces, so large that it appears out of the question to build all structures to resist them. Throughout, the report opens up many more questions than it answers. Yet its positive value is unmistakable.

"Tornado effects are so large, unexplained and unexplainable that they are a more fruitful field for the exercise of imagination than for the application of numerical calculations. Yet we must make progress through calculation, and discount and distrust all fancies, however plausible.

"Almost everywhere in the path of the storm, effects of utmost violence appear close beside exhibitions of resistance that suggest relatively moderate forces. We find projectiles driven through trees and walls, and only a few feet away frail structures left almost uninjured. We find two neighboring structures, the stronger destroyed and the weaker surviving. Concerning every fact and datum of the storm, it may almost be said, comparison or collation with other facts and data is impossible without risk of serious error. The tremendous velocity effects present in tornadoes are of quite unknown size, but it may well be, on the evidence of some of the facts, that they are of small areal extent, mere filaments of extreme velocity in the general swirl of the air currents. At any rate in the present tornado, no force actions of large area have been evaluated at such exceedingly great figures as would correspond to observed projectile effects. Amid these confusions and contradictions progress necessarily must be made by chance steps rather than by system.

"Such a chance step constitutes the most important yield of the Illinois storm study, as expressed in the conclusions of the engineers. Briefly stated, it is that the most disastrous failures in the storm path were due to or were aggravated by faulty construction. Bonding, anchorage and bracing were neglected. Included among the defects is the inadequate construction of the roof of the high school gymnasium in Murphysboro, where the

heavy steel roof was set on high walls like a heavy table top on rickety legs—an expression of optimistic hope that nothing rude or violent would come along to push it over. School architecture, in fact, made here a definite record of disgrace.

"Clearly, the architectural and engineering practices of quieter regions are not suited to the tornado belt. Rule-of-thumb architectural construction is out of place in any public building, but most of all in regions where these intense, unaccountable storms may occur. We have not yet progressed to the point where complete calculation can be applied to making buildings proof against tornadoes, and the data on which to base such calculations are as yet only highly speculative first guesses. But, pending further progress, we have some substantial reasons for concluding that the most solid and thoroughly braced portions of these buildings were inherently strong enough to weather the worst violence of a Mid-West tornado, while the weaker portions were far too weak to survive. We may fairly conclude, then, that a very great increase in public safety may be secured by avoiding the local weaknesses exhibited in these structures, by tying them together thoroughly, by carrying the main elements of framework through to a substantial foundation with adequate anchorage, and in general by making the entire structure integrally as strong as its best built and strongest parts.

There is some opportunity, also, though concededly less complete, for improvement in ordinary frame dwelling-house construction. Here also anchorage, tying and bracing are of controlling importance. Until the efficacy of frame construction properly provided with such safeguards is tried out by storm, it is futile to endeavor to conclude with positiveness either for or against the inherent risks of the type of construction.

"Tornadoes are not irresistible, as many people fatalistically believe. Through the study of tornado effects we will learn how much strength must be provided to resist them. The present report is a beginning. Ultimately it should be possible to compile a consistent body of data ranging over the whole field of tornado action, if the present beginning is taken as an example by structural engineers throughout the world's tornado areas and encourages them to seize whatever opportunities may come to them to carry out similar investigations.

Armour Branch Elects Officers

At our election on April 23 the following were elected as officers of the Armour Branch, Western Society of Engineers for the following year.

President—G. O. Melby
Vice Pres.—N. J. Wagner
Treasurer—E. J. Jaros
Secretary—T. S. Schaefer
Ass't. Sec.—J. D. Green
Student Rep.—C. M. Nelson
Faculty Rep.—Prof. M. B. Wells

Respectfully submitted,
T. S. Schaefer, Secretary.

Societies Join in Elimination of Waste in Industry

The work being done by the United States Department of Commerce Division of Simplified Practice, for the elimination of waste in Industry is well known. Thirty-eight commodities have been studied of which thirty are definitely standardized by the manufacturing industry and eight are now in process of standardization. It should be understood that this standardization is merely a decision and agreement on the part of the manufacturers to eliminate the sizes or varieties of their product which are infrequently used and concentrate on the most common sizes or varieties. As an example of some of the things that have been accomplished might be mentioned, the varieties of vitrified paving brick, reduced from 66 to 4, bedsprings and mattresses from 78 to 4, hotel chinaware, from 700 to 160, files and rasps from 1351 to 496 rough face brick from 39 to 1 and so on down the list of thirty-eight commodities already studied.

In studying the simplification of milling cutters, the Department asked the Western Society of Engineers to accept a reduction of about 35% in the number of varieties manufactured. The blank sent to the Society was the regular form sent to manufacturers or distributors and did not apply to a technical society. Our Secretary suggested to the Department

of Commerce that there were a number of technical organizations which would be glad to give their support to this movement, if there were proper means for them to do so. As a result the Department of Commerce has drawn up a form which it is circulating to interested technical organizations, asking them to signify their acceptance of the principle of the recommendation and their intention to use their best efforts to secure a general adherence to the simplified list of stock sizes and dimensions by their members. The correspondence with the Department of Commerce indicates it's appreciation of this suggestion. In the present inquiry into the manufacture of milling cutters, twelve interested organizations have already signified their approval, although they are not themselves producers, distributors or users of milling cutters.

Durability of Brown Print Paper Conserved If Kept at Right Temperature

Coaters and users of brown print paper, largely used by engineers and draughtsmen in making copies of drawings, should keep undeveloped sensitized paper at a temperature of not more than 35 to 40° F. in order to conserve its durability, according to T. D. Jarrell and F. P. Veitch of the Bureau of Chemistry, United States Department of Agriculture, in a recent report on the "Effect of Temperature and Time of Storage on the Physical Properties of Undeveloped Brown Print Paper."

The effect of the commonly employed brown print sensitizing materials used in this country on the folding endurance, bursting and wet tensile strengths of the paper to which the materials had been applied, was investigated. At intervals of one to twenty weeks after storing the undeveloped coated rolls of paper at 35 to 40° F., 55 to 60° F., 70° F., and 86° F., samples were taken from the various rolls, and then developed, washed and air dried. The physical tests were made on these samples.

It was found that the temperature at which undeveloped coated brown print paper is kept between the period of coating and drying, and that of developing and washing, influences the effect of the sensitizing materials upon the physical properties of the paper.

Undeveloped brown print paper can be kept at 35 to 40° F. for at least five months without any deterioration in strength. However, as the temperature is raised, the deterioration becomes marked.

When stored for two weeks at 55 to 60° F. the folding endurance is decreased about 30 per cent, and the bursting strength is decreased about 5 per cent. The folding endurance and bursting strength are decreased about 45 per cent and 8 per cent, respectively, when stored for two weeks at 70° F. When stored for two weeks at 86° F. the folding endurance is decreased about 80 per cent, and the bursting strength is decreased about 20 per cent. As the period of storing the undeveloped coated paper at these temperatures is prolonged, the folding endurance and bursting strength progressively decrease.

Studies Vitrified Paving Brick

The Permanent Committee on Simplification of Varieties of paving brick held its fourth revision conference in Washington, D. C., this spring. The Western Society has been interested in this movement, having sent a delegate to the first conference.

Reports presented showed that forty-six companies, having a total annual tonnage capacity of 2,724,567 tons, or 92 percent of the total tonnage capacity of the entire industry, answered the 1924 questionnaire. These companies reported actual shipments of 399,993,140 vitrified paving brick during 1924,—84.1 percent of which was within the five recognized types and sizes.

The application of the elimination formula was much in evidence when the Committee considered the 3x3½x8½" wire cut Lug Brick (Dunn), which has always been a recognized type. The percentage of this size was 2.1 in 1922, 2.3 in 1923 and 2.0 in 1924, which is below the 2½ percent for three successive years. This size was eliminated.

Reports were presented showing the work done in the past year toward educating engineers to confine their specifications to recognized sizes.

New Books

627.3
C973c

Cargo handling at ports.

By Brysson Cunningham. New York, Wiley, 1924. 180p. Illus., tables, fold. plans.

A book which presents a variety of data gathered by an engineer of authority on this subject. The chapter headings show the kinds of material treated: Cargo: varieties and characteristics; Cargo carriers; Quayside cargo facilities; Quay cranes; Burtoning; Conveyors and elevators; Trucking; Lighterage; Coal handling; Ore handling; Grain cargoes; Refrigerated produce; Fuel oil; and Whole timber cargoes.

621.331
B636e2

Electric railway transportation.

By H. W. Blake and Walter Jackson. 2d ed. New York, McGraw, 1924. 437p. Illus.

A revised edition of this handbook on the transportation side of the electric railway business—getting the cars over the tracks, increasing the traffic, collecting the fares, and selling the service. The volume has been reset with new examples from recent practice and with new material on the place of the bus in the present day transportation scheme.

666.9
L633h

History of the Portland Cement industry in the U. S. with appendices covering progress of the industry by years and an outline of the organization and activities of the Portland Cement Association.

By R. W. Lesley in co-operation with J. B. Lober and G. S. Bartlett. Chicago, International Trade Press, 1924. 330p. Illus., tables, diags.

A comprehensive treatise tracing in minute detail the experiments preceding the discovery of Portland Cement, its discovery by Aspdin, its development and use all over the world.

The volume is replete with data concerning the historical development of the many companies producing Portland Cement in this country, and also concerning the men whose vision haave made this development possible.

After a view of the industry has been presented, several chapters are devoted to description of the mechanical processes involved in manufacturing, to a study of the progress made in this line, and to a discussion of the spirit of research and scientific organization which pervades the industry.

The story of the growth of the cement industry is romantic and inspiring. This book is as fascinating as fiction.

669.7
A549m

The metallurgy of aluminum and aluminum alloys.

By R. J. Anderson. New York, Baird, 1925. 913p. Illus., tables, diags.

Designed to fill the need for a complete, practical treatise on the metallurgy of aluminum for the use of metallurgical, automotive mechanical, chemical and electrical engineers as well as the engineering schools. The history of aluminum is traced from the ore through its extraction, foundry manipulation, rolling mill or other fabricating operation to the finished product. The properties, micrography and macrography of aluminum and its alloys are treated in detail. Selected bibliographies at the end of all chapters add greatly to the value of the book.

NEW REFERENCE BOOKS

624.08
K22s3

Structural engineers' handbook.

By Milo S. Ketchum. 3rd ed. enlarged. N. Y., McGraw, 1924. 1065 p. Tables, diagrs.

In this edition the book has been revised and partially rewritten—more than 130 pages of new material has been added. The most important additions are: Design of self-supporting steel stacks; steel column footings; and the American Institute of Steel Construction's Specifications for structural steel for buildings. Tables and standards have been brought up to date. New material has been added on steel mill buildings, steel office buildings, steel and timber highway bridges, steel railway bridges, electric traveling cranes, and retaining walls. The sections on stresses in stiff frames and in eccentric riveted connections have additional data.

621.08
K37m10

Mechanical engineers' handbook.

By William Kent. 10th ed. rewritten by R. T. Kent and a staff of specialists. N. Y., Wiley 1923. 2247p. Tables. diagrs.

A standard handbook containing new material and new tables in this edition. The sections on fans and blowers, hydraulic turbines, pumps and pumping engines, oil engines and gas producers, refrigeration, heating and ventilation have been rewritten. New sections include gas turbines, automobiles vehicles, aeronautics, fusion welding and cutting, malleable casting, reinforced concrete, and safety engineering.

697
H441d

Data sheets on heating and ventilation.

N. Y., Heating and Ventilating Magazine, 1924. Loose leaf tables.

A handbook containing in table form innumerable computation required daily by the heating and ventilating engineer. A few of the subjects covered are: B. T. U. losses, air changes, radiation computation, sizes of ducts and flues, chimneys, flow of steam, pipe covering, steam heating, vapor heating, and water heating. The loose leaf form allows for constant revision and addition.

Chicago Daily News Almanac and Yearbook for 1925.

Ed. by James Langland. Chicago Daily News, 1924. 1024 p.

BOOKS ADDED TO LIBRARY

Connecticut. Public Utilities Commission. Annual Report. 1923-24.

Illinois. Division of Waterways. Annual Report. 1923-24.

Interstate Commerce Commission. 37th annual report on statistics of railways in the U. S. for the year ended Dec. 31, 1923. 1925.

Iowa. Geological Survey. Annual Report. v. 30. 1924.

New York. Transit Commission. Annual Report. 1923.

Ohio. Geological Survey. Bulletin. 4th Series. No. 28. 1924.

Canada. Dept. of Mines. Mining laws of Canada. 1924.

Carnegie Institution of Washington. Yearbook. v. 23. 1924.

Chicago. Dept. of Public Works. Annual report. v. 48. 1923.

Engineering Assn. of Malaya. Transactions. v. 3. 1924.

Illinois Engineering Experiment Station. Bulletins 135-142; Circular 10. 1924.

Institution of Engineers and Shipbuilders in Scotland. Transactions. v. 67. 1924.

Massachusetts. Dept. of Public Health. Annual report. 1923.

New York. Transit Commission. Annual report. 1922.

New York. Transit Commission. Summary of the annual report. 1924.

U. S. Engineer Dept. Annual report. 1921-1924. 9v.

U. S. National Advisory Committee for Aeronautics. Annual report. 1924.

U. S. Public Health Service. A study of the pollution and natural purification of the Ohio River. II. Report on surveys and laboratory studies. 1924.

The Degree-Day, New Term to Measure a Hard Winter

The "degree-day" is a new term invented by gas and fuel engineers for the purpose of measuring heating requirements, and appears for the first time in "House Heating," a book recently published under the auspices of the American Gas Association.

With the increasing demand for city gas for house heating and industrial heating purposes it became necessary to have some word or phrase which would enable engineers to make comparisons between heating loads under different climatic conditions or at different points. The "degree-day," which was the result, is the product of a degree of temperature and a time factor of one day.

In studying actual domestic heating conditions, the American Gas Association determined that the minimum temperature of bodily comfort in the home is reached when the mean daily temperature falls below 65° F. In other words, below this point, heat is required, as the average day-time temperature in the house drops below 70° F.

If, then, we have a mean daily temperature of 60° F., it is evident that, for this day, we can measure the heat requirements by the figure "5° days," whereas, had the mean temperature been 55° F., the requirement would be measured by "10° days," or would be twice as great. For a week or a month or a heating season, the aggregate heating load of any locality may be expressed in units that permit comparison with that of any other point. Likewise the heating requirements at any given place during the heating season may be compared with those of any other heating season by the "degree-day." So a "mild winter" or a "hard winter" becomes definable in accurate units that may be translated into B. t. u. Basing theses units on the very accurate data of the weather bureau a high degree of accuracy results.

Lehigh Starts New Engineering Course

Cross-breeding the engineer with the business administrator is the interesting experiment that will be launched at Lehigh University next September, according to an announcement of the inauguration of a new curriculum to be known as Industrial Engineering. Recognizing that every modern enterprise depends on sound financing, adequate accounting and intelligent forecasting of economic developments, the faculty at Lehigh will undertake to produce en-

gineers as thoroughly grounded in these fundamentals of business as in their mathematics, physics and scientific subjects. The curriculum is primarily engineering in character and will equip the student with sufficient technical knowledge to make him at home in a highly technical environment. In addition, however, it will include courses in economics and business that will be of service to those graduates who enter the less technical departments of any of the various industries which are essentially technical in character. The course will lead to the degree of Bachelor of Science in Industrial Engineering.

The same announcement gives notice of the discontinuance of the course in Marine Engineering, the enrollment in which had fallen off to such an extent as to convince the authorities that there is not sufficient demand for such a course.

APPLICATIONS FOR MEMBERSHIP

Members of the Society can be of great service if they will make a practice of examining the list of applicants published herewith and promptly notifying the Membership Committee or the Secretary regarding the qualifications of any of those whose names appear on the list. The Society desires to extend its membership and receive those engineers who have the proper qualifications and wish to participate in its activities. The following applications have been received since last report:

No.	Name	Address
89—1925	Walter A. Himmelreicher	3109 N. Kimball Ave., Chicago, Ill.
90	S. M. Quinn	C/o Hotel Hayes, 64th St. and University, Chicago, Ill.
91	Fred Weber (Transfer)	149 Broadway, New York City.
92	Ralph A. Hibner	3926 N. St. Louis Ave., Chicago, Ill.
93	George E. Stevens (Transfer)	15 Anderson St., New Rochelle, N. Y.
94	Harold J. McCreary	3210 Arthington St., Chicago, Ill.
95	John A. Whitaker	311 S. Ridgeland, Oak Park, Ill.
96	Burr J. French	5512 Flournoy St., Chicago, Ill.
97	Fred M. Lyon	836 S. Michigan Ave., Chicago, Ill.
98	Edward Mundt (Transfer)	Lloyd, Montana.
99	Henry T. Fisher	6127 Woodlawn Ave., Chicago, Ill.
100	Lester I. Moore	3444 Wenonah Ave., Berwyn, Ill.
101	A. A. Summerfield	401 Dowie Bldg., Chicago, Ill.
102	Kenneth F. Whitcomb	5616 N. Karlov Ave., Chicago, Ill.
103	Richard H. Tobbin	5903 Eggleston Ave., Chicago, Ill.
104	Lyman L. Browne	414 N. Stone Ave., La Grange, Ill.
105	Alfred G. Schutt	826 N. Ridgeland Ave., Oak Park, Ill.
106	Carroll E. Robb (Transfer)	168 N. Michigan Ave., Chicago, Ill.
107	H. C. Friedman (Transfer)	2241 Clifton Ave., Chicago, Ill.
108	Robt. K. Tullis (Transfer)	604 Daniels St., Toronto, Ohio.
109	Chester R. Andrzelozyk (Transfer)	851 N. Ashland Ave., Chicago, Ill.
110	Charles J. Hageman (Transfer)	Newark, Delaware.
111	Orlando C. Kohli (Transfer)	923 N. Main St., Lima, Ohio.
112	B. J. Rauchfleisch (Transfer)	1837 W. Monroe St., Chicago, Ill.
113	Arthur H. Swanson	209 S. Catherine Ave., La Grange, Ill.
114	Jack Rich (Transfer)	6122 N. Paulina St., Chicago, Ill.
115	Mack G. Burkey (Transfer)	4408 Lake Park Ave., Chicago, Ill.

APPLICATIONS FOR MEMBERSHIP—(Continued)

116	Guy E. Soper (Transfer)	Orland, Maine.
117	Jerome H. Linden (Transfer)	7724 S. Morgan St., Chicago, Ill.
118	Glenn N. Romine (Transfer)	New Boston, Michigan.
119	H. N. Genkinger (Transfer)	747 Hinman Ave., Evanston, Ill.
120	George F. Weinheimer, Jr.	4108 Grenshaw St., Chicago, Ill.
121	Robert A. Granger (Transfer)	319 W. Ohio St., Chicago, Ill.
122	C. H. Langworthy (Transfer)	203 Embassy Apts., Portland, Oregon.
123	E. Chris Mahnke (Transfer)	1400 E. 53rd St., Chicago, Ill.
124	Harold E. Tabbert (Transfer)	Hobart, Indiana
125	Theophilus Schmid, Jr (Transfer)	10856 Wabash Ave., Chicago, Ill.
126	Willard L. Alford (Transfer)	3247 S. Michigan Ave., Chicago, Ill.
127	Edgar R. Safarik	1301 N. Parkside Ave., Chicago, Ill.
128	Samuel A. Burger (Transfer)	5306 N. Winthrop Ave., Chicago, Ill.
129	Michael Raphael (Transfer)	621 Harrison St., Davenport, Iowa.
130	Harry Bernstein (Transfer)	3539 Flournoy St., Chicago, Ill .
131	Bernard E. Lindstrom	467 S. 4th St., Aurora, Ill.
132	Morris D. Krausman	6006 S. Halsted St., Chicago, Ill.

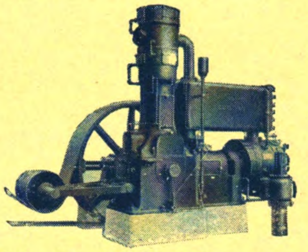
NEW MEMBERS

The following were elected to membership by the Board of Direction at its meeting held May 18, 1925:

No.	Name	Address	Grade
62—1925	Jacob Souderegger	1457 E. 69th Pl., Chicago, Ill.	Junior
63	Samuel E. Berkenblit	3214 Hirsch St., Chicago, Ill.	Member
64	Edwin Schwarz	3333 S. Michigan Av., Chicago, Ill.	Student
65	James A. Davidson	4626 N. Hermitage Av., Chicago, Ill.	Student
66	John H. Parsons	506 S. Darling St., Angola, Ind.	Student
67	Curtiss J. Peterson	400 S. College St., Angola, Ind.	Student
68	Paul A. Millis	718 W. Prospect, Angola, Ind.	Student
69	A. J. Bain	1023 Addison St., Chicago, Ill.	Member
70	Frank A. Coy	1629 Wilson Ave., Chicago, Ill.	Member
71	Christen Christensen	710 W. Madison St., Chicago, Ill.	Member
72	Ray M. Ring	2131 S. Michigan Ave., Chicago, Ill.	Affiliate
73	Thomas Blair	156 E. Pearson St., Chicago, Ill.	Associate
75	D. J. Underwood	520 Old Colony Bldg., Chicago, Ill.	Associate
77	Melville N. Larson	2141 Sherman Ave., Chicago, Ill.	Student
78	Arthur H. Allyn	4844 Winthrop Ave., Chicago, Ill.	Associate
79	Charles A. Wickstrom	137 Woodland Ave., Western Springs, Ill.	Member
80	C. Winslow Henkle	5309 Greenwood Ave., Chicago, Ill.	Junior
81	E. J. Williams	311 E. Gilmore St., Angola, Ind.	Student
83	Harold H. Gates	847 Monadnock Block, Chicago, Ill.	Assoc.
84	James Hugh Moylan	1727 Wabash Ave., Flat C, Chicago, Ill.	Affiliate
85	John Humphries	413 S. College St., Angola, Ind.	Student
86	James M. Kennedy	122 Arlington St., Winnipeg, Man., Can.	Student
87	Jesse H. Grant	Transcona, Manitoba, Canada	Junior
88	Arthur W. Gustafson	4141 Clarendon Ave., Chicago, Ill.	Associate

SULLIVAN

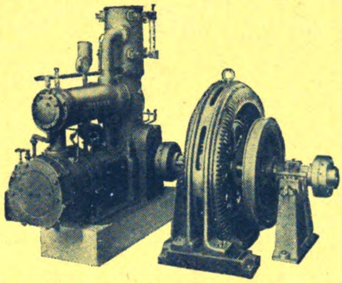
THE BEST IN AIR POWER SERVICE



"WJ-3" Angle Compound Compressor, belt driven.

"Angle Compounds"

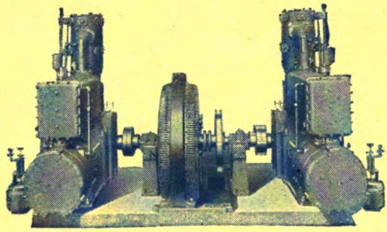
stand for distinctively "Sullivan" Compressor Service. They embody an efficiency in power input, an adaptability to drive and capacity requirements, a floor space economy and a reliability in performance which have been quite unmatched since Angle Compounds were first marketed a dozen years ago.



"WN-3" Angle Compound, direct connected to motor.

Sullivan Angle Compound design achieves a perfect balance of the moving parts and forces. These machines run without perceptible vibration; hence smaller foundations and higher speeds are permissible.

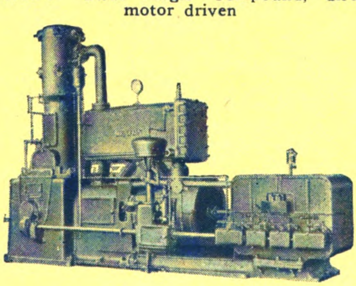
Wafer Air Valves throughout, and three-pass counter current copper intercoolers assure high volumetric efficiency.



"WN-4" Twin Angle Compound, direct motor driven

The Sullivan Automatic load and capacity control, proportions the power used exactly to the work done. Belt drive, direct connection to motor or oil engine, single units to 1800 cu. ft., twin units (each half twin a complete two-stage compressor) to 3700 cu. ft. These are some Angle Compound high lights.

Ask for Catalog 2077-H.



SULLIVAN ENGINEERS have extended the usefulness of angle compound design to the steam driven field, by placing a modern high duty steam cylinder tandem with the horizontal air cylinder. This steam end is of the direct flow, high compression type, and secures excellent fuel economy. Wafer Valves throughout. 1100 cu. ft. and upward. Bulletin 2077-F.

SULLIVAN MACHINERY COMPANY
122 So. Michigan Ave. Chicago.

WESTERN SOCIETY OF ENGINEERS FOUNDED 1869

SOCIETY BADGES

Gold badge, with blue enamel, for Members and Associate Members - - - - - $3.00

Silver badge, with green enamel, for Junior Members and Affiliated Members - $2.00

Silver Badge with Red Enamel for Student Members - - - - - - - - - - - - - $1.00

Apply to the Secretary

JOURNAL of the WESTERN SOCIETY of ENGINEERS

PUBLISHED MONTHLY

JULY, 1925

In this issue:

Vol. XXX No. 7

WESTERN SOCIETY OF ENGINEERS FOUNDED 1869

$ 3.00 THE YEAR 50¢ THE COPY

JOURNAL OF THE
WESTERN SOCIETY OF ENGINEERS

Volume XXX JULY, 1925 Number 7

Our Rooms Being Rebuilt

THE SOCIETY is taking advantage of the summer vacation to rebuild its quarters on the top floor of the Monadnock Building, which has been its home for the past thirty years. A new lease has been negotiated, for a three year term, covering Rooms 1735 and 1736.

It has been realized, that the Society was not making the most efficient use of the space on which it was paying rent. Due to certain changes in conditions, some parts of the rooms were not being used as actively as they were at the time the quarters were remodeled in 1911, while other parts, notably the Library, were severely overtaxed. Accordingly, an entirely new layout was developed and is now being built.

The accompanying drawing gives a floor plan of the new arrangement. From it, it will be noted that the entire Library has been moved to the west side of the building. The meeting room has been made narrower and longer, and the general and private offices have been moved to the east side of the building, formerly occupied by the library.

By this arrangement, a number of the improvements are effected. The capacity of the Library has been increased and the shelves have been arranged so that the books are now located in their correct order, with ample room for expansion. The reading room is now separated from the rest of the Society's space, so that it can be kept quiet. The readers will be located convenient to the librarian's desk.

The business offices of the Society are located on the east side of the building. The general office is nearest the entrance, with the telephone operator and information desk immediately in front of the door. Adjacent to the general office is a small room, which will be used for the storage of supplies, the addressograph and duplicating machines. The walls of this room will be lined with shelves, providing storage space for stationery, which can thus be kept in an orderly manner, and good condition. A hallway which is fitted with coat hooks, to serve as a coat room on meeting nights, leads to the private offices of the Editor, the Secretary and to a Conference Room, which will be used by the Board of Direction and committees for small meetings.

The auditorium still occupies the center of the building. Its capacity has been increased to 204 permanent seats, instead of 180 as heretofore. The screen will be extended to the west, so that the speaker will occupy a position on the right side of it and nearly in the center of the room. Under the new arrangement, a full view of the speaker and the entire screen can be had from every seat in the room, which was something that could not be said of the old plan, on account of the four large columns. There is a large ventilating fan in the attic, just above the reading room, which will be used to exhaust the air from the auditorium on meeting nights. Fresh air will be taken from halls and other offices, where it passes over the radiators located directly under the windows. It is thought that this arrangement will overcome the criticisms, regarding poor ventilation, that have been heard since our old ventilating equipment was burned out some time ago.

The Employment Service will be located in Room 1736, which is served by a connecting doorway and also has direct entrance from the main hall.

The different departments of the Society's offices heretofore have been so widely separated, as to interfere somewhat with the efficient working of the offices. The new arrangement will be compact and efficient.

These alterations will cost nearly $5,000.00, one-half of which is to be borne by the Society. In return for this we get a larger and more efficient Library, better arranged offices, a small conference room, a meeting room with more seating capacity and a better general

arrangement of facilities. Because we occupy less total space than heretofore, the rent remains the same as it has been. In case it becomes necessary for the Society to take on more space, it has the option of renting adjoining rooms, which are now temporarily occupied by some of the offices.

Members are invited to drop in and look over the new quarters whenever it is convenient for them.

Members Win Prizes

Announcements have been made recently of the winning of prizes by two of our members.

Clyde N. Robinson, a Junior member won the second prize of $300.00 in the Employees Home Lighting Contest of the National Electric Light Association. The award was made at the annual convention in San Francisco during the week of June 15. Mr. Robinson has been with the Public Service Co. of Northern Illinois since his graduation from the University of Illinois in 1922. He took second place in the contest which is arranged for employees of public utility companies.

L. R. Davis, M. W. S. E. Secretary, of the Business Research Corporation, 72 West Adams street, entered the competition for the Bonbright Prize which was announced in the March number of our Journal. A total of $10,000 in prizes ranging from $5,000 down to $100 was offered for the best contemporary review and forecast of the Electric Light and Power Industry. There were 478 contestants among which Mr. Davis ranked eighteenth, winning one of the $100 prizes. There is a supplementary prize of $10,000 to be awarded in 1930, to that contestant whose paper again reviewed, shall appear at that time to have most nearly approximated the facts as they developed. Mr. Davis was the only one among the prize winners who lives in Chicago.

Albert Boswell, Aff. W. S. E., Associate Editor of *Chicago Commerce* has been obliged to move to Los Angeles, Calif., on account of the health of his young son. He will probably make his permanent residence there.

Why We Register at Meetings

Perhaps our members sometimes wonder why we ask them to sign registration cards, whenever they attend society meetings, some no doubt thinking it a useless nuisance to be imposed upon them. However, these cards contain data of considerable value to the members and staff in charge of these society functions. Many times changes in business connections and addresses are caught by means of these cards which would otherwise be delayed or never show up on the office records.

This year, under the direction of Mr. Rabbe, much valuable information has been taken from these cards and tabulated for the benefit of the Committee and the Secretary's staff. After each meeting the names of members and non-members attending, are separated and recorded on file cards; a separate file being kept for each group.

From these cards we learn that of the 6,717 people attending the 38 technical meetings, held during the past season, 85% have signed registration cards, recording their attendance.

Fifty-one percent of those registering were members of the society, while 30% were members of neither the Western Society nor of any of the four Founder Societies.

A further study shows that 59% of our resident membership failed to attend a single technical meeting. However, many of these members did attend Committee, Luncheon, Excursion or other meetings and were otherwise active in the affairs of the Society.

361 resident members attended 1 meeting
182 resident members attended 2 meetings
32 resident members attended 5 meetings
14 resident members attended 10 meetings

Two, R. L. Lawson and L. M. Traiser, each attended 24 meetings, while five, W. K. Flavin, E. A. Howes, J. H. S. Hodgson, Grover B. Morgan and W. M. Randolph, each attended 25 meetings, an average of almost three meetings a month.

The following table shows an interesting comparison of the attendance at

Section	Total Attendance	Number of Meetings
Electrical	1685	5
Mechanical	1125	5
Bridge and Structural	936	5
Tel. and Tel. and Radio	735	4
Railroad	685	5
Gas	587	4
Hydraulic, Sanitary and Municipal	575	5
Illuminating	389	4

Largest meeting and attendance:

Mercury Vapor Boiler and Turbine	530
The World Flyers	450
Tribune Tower	300
Transmitting Pictures by Wire	270
I. C. R. R. Terminal Improvements	240
A New Design of Gas Holder	153
Dix River Hydro-Electric Development	160
Street Lighting	95

meetings under the auspices of the various sections.

The electrical, mechanical and illuminating sections held their meetings jointly with the Chicago Sections of the corresponding national societies. It was necessary to hold four of these meetings outside of our rooms because of the large attendance. The Hydraulic, Sanitary and Municipal Engineering Section is unique in that it is the only section in which all the papers were presented by W. S. E. members.

In comparing this year with the past five, we find a gratifying increase in attendance.

Year	Number of Meetings	Total Attendance	Average Attendance
1920-21	47	5,159	111
1921-22	45	6,507	145
1922-23	38	6,592	174
1923-24	35	6,200	177
1924-25	38	6,717	177

In the meetings other than those on the Monday night technical program, there has been a good increase in attendance, more than 3,000 persons attending these functions. Briefly these were as follows:

Six noonday Luncheons, six Excursions, four Social meetings, fifteen meetings and inspection trips of the Young Men's Forum, two day-sessions of the Mid-Winter Convocation, Convocation Dinner, Summer Boat trip to Michigan City and the Annual Dinner.

Over 250 members have been active in committee work this year.

The undertakings of the Society are receiving more and more attention from the professional men of Chicago because they are supplying activities necessary to professional and civic growth.

The record given above is an indication of the interest of non-members and shows the possibilities for increasing our membership.

1925 Convention of the Illuminating Engineering Society

The nineteenth Annual Convention of the Illuminating Engineering Society will be held during the week of September 14-18 at Detroit, Mich., with headquarters at the Hotel Statler.

A well-rounded papers program is being arranged by the Committee on Papers. A complete session will be devoted to motor vehicle lighting with papers by a a number of well-known authorities, covering such topics as state regulation of headlights, depressible beam headlighting and the latest developments in traffic control systems. Another session will be set aside for a symposium on natural lighting which will be held under the leadership of the Society's Committee on Natural Lighting. There will also be a symposium on residential street lighting. Among the other topics which will be discussed are: show-window lighting, high intensity industrial lighting, floodlighting, computations, recent developments in Neon lamps and photometry of asymmetric lighting units.

An entertainment program containing a diversity of features which will make it of unusual interest is being prepared.

Linn White, M. W. S. E. Chief Engineer, South Park Commissioners reports that two instruments were stolen from his department June 25 and thinks it possible that they may be offered for sale to some member of the Society. The instruments are one Buff and Buff transit, serial No. 8027 and one Seelig

level No. 938. These were taken from a car standing near the South Park Commissioners Office at Washington Park. Mr. White will appreciate being advised of their whereabouts in case they are offered to any of our members for sale.

Samuel T. Smetters, M. W. S. E. left on July 1 for a three months' trip to South America. He has been retained as special consultant for the Buenos Aires and Great Southern Railroad and will spend some time in the Argentine Republic.

H. S. Shimizu, M. W. S. E. Assistant Engineer, Roberts & Schaefer Co., left Chicago July 9 to return to Japan. It is his plan to establish connections with several American companies doing business in Japan and specializing in engineering construction. He has been a member of the Western Society of Engineers since July, 1911.

It is gratifying to note that payment of dues by the members is proceeding at a somewhat more rapid rate than last year.

The dues of members are payable June 1 each year. A year ago 32½% of our members paid their dues before July 1. This year the percentage is 40½ at July 1. If we can only keep up this rate, it will mean that the Society will be able to divert a considerable amount of its funds to more useful purposes, than in years past.

The Sullivan Machinery Company announces the appointment of Raymond B. Hosken, M. W. S. E. as General Sales Manager of Domestic Sales for that company.

This is effective July 1st, 1925. Mr. Hosken has been attached to the Sales Department of the Sullivan Machinery Company since his graduation from the University of Michigan in 1910. After four years in the local Sales Department at Chicago, he was appointed Australasian Manager with headquarters at Sydney, N. S. W., where he remained until 1921, when he was appointed Assistant to Howard T. Walsh, Vice President in charge of Sales at Chicago.

To Study Earth Roads

A national investigation on the Development of Earth Roads is to be started at once by the Highway Research Board of the National Research Council. The object of this investigation is to coordinate the efforts and data already available on the improvement of earth roads and to stimulate further research in order to find an inexpensive surface that will carry secondary traffic at low cost of construction and maintenance. The investigation will be under the direction of Prof. S. S. Steinberg of the University of Maryland.

Improvement In Patent Office Conditions

Engineers having any dealings with the United States Patent Office will be interested in the following statement coming from the Department of Commerce:

Decided improvement in the status of work at the Patent Office is shown in the first detailed report submitted to the Secretary of Commerce since the office was transferred to the Commerce Department on April 1 last.

Despite the receipt of 1900 more new applications and 30,000 more amendments than during the previous year, Commissioner of Patents Robertson in his statement to Secretary Hoover, reports that the close of the last fiscal period found the Patent Office with 16,000 fewer cases awaiting official action than a year ago.

There were only 43,000 cases pending on June 30, last, against 59,000 a year ago; 72,475 on June 30, 1923; and 67,608 at the end of the fiscal year 1922.

A year ago but one examining division had its work less than three months behind. There are now 5 under 2 months and 14 under 3 months.

Thirty-six divisions have succeeded in reducing their work to a four-months basis against only 2 in this class last year, while 48 others have gotten their work to a 5 months basis against only 8 in this class a year ago.

Last year at this time there were 40 divisions over 5 months, 26 over 6 months, 9 over 7 months and 2 over 8 months. Now there are only 5 divisions over 5 months and none over 6.

According to the Patent Commission-

er's report, during the year just closed his office has decreased the average time that application must await official action by 2 months in new work and 1 month in old work so that the average time that a new application must await to receive official action has been reduced from 5 months to 3, and the average time an amended application must await official action has been reduced from 3.4 months to 2.3 months.

W. T. Krausch, M. W. S. E. Engineer of Buildings, C. B. & Q. R. R. Co. returned to his office July 1 after an absence of more than three months, on account of illness. The past two months he has spent in California recuperating. He feels that his recovery is complete and that he is now ready to resume his duties.

Recently the American Society of Mechanical Engineers has approved the use of the term "engineman," instead of engineer, when referring to positions of which the duties are operation, maintenance or repair of stationary or moving engines. This is in use by a number of publications which recognize the difference between an engineer and the operator of an engine.

Here in Chicago engineers have good reason to favor such a distinction. The Board of Education calls the man who has charge of a school building an engineer. The real engineering work of the Board of Education is done by a separate staff, which is maintained as an engineering department. The men that they call engineers of school houses have charge of the work of keeping the buildings heated and cleaned, which involves principally fireman and janitor service.

It is to be hoped that other organizations will take steps to establish the distinctive character of real engineering work in the public mind.

BOOK REVIEW

Estimating Building Costs and Appraising Buildings, by Frank E. Barnes, C. E.

The author, in his preface, states: "The fundamental purposes of this book are three-fold, (1) to aid the contractor or estimator in determining the amount of labor required for the various building operations; (2) to furnish him with prices of labor and materials which will enable him to check his estimates and (3) to equip him with full data on the present day costs of replacing various types of existing buildings built between 1890 and 1923 which will serve both as the basis of appraisals and as checks and guides in estimating similar buildings." Continuing in the preface: "The author does not advise using the prices in this book for any but approximate or rough estimating. They are for the purpose of giving a general idea of present day costs. Some of them will have changed before this book is off the press. Local conditions will also tend to affect the cost of the work, but having the labor hours and the bill of materials, it will be a simple matter to apply local prices to obtain an accurate estimate of any type of building construction."

The work is addressed to the contractor and estimator. If by estimator is meant one who is regularly engaged in estimating, it might also be addressed to the architect and student, for these should form a good percentage of its users. It is suited to their use because of the considerable amounts of descriptive material and trade information which are not so generally available to architects and students.

The author's warning regarding the approximate character of cost data should always be kept in mind in the use of any book on estimating. This is particularly true of labor, which varies not only in wage rates, but even more in efficiency.

This book of eight hundred pages is made up of twenty-nine chapters which may be classed as follows:

One chapter, introductory; twenty-five chapters, each covering one trade or material; one chapter, useful data; one chapter on appraisal; one chapter on depreciation.

The scope is quite complete, including all the materials and labor commonly used in the complete construction of a building.

The treatment of the individual subjects varies in thoroughness. In some chapters there seems to be an undue amount of space given to description and specification. Thus, in the chapter on "Painting" eight pages, quoted from a Government publication, contain very little information pertinent to estimating. Similarly, in the chapter on "Structural Steel" nearly twenty pages of specifications are quoted. These specifications can have little bearing on cost estimating and are readily obtainable elsewhere, if needed.

There is, doubtless, some advantage in having all estimate data contained within one book, but it is doubtful whether it justifies repeating material that is easily referred to in other books or catalogs. Space saved by the omission of such items could be used for additional valuable cost data. This comment applies particularly to twelve pages of standard tables of quantities of materials for reinforced concrete; to fourteen pages of weights of structural steel sections and fittings; and to seventy-two pages of catalog material covering finish carpentry and millwork. In these cases and some others reference to the original sources would serve quite as well. Like consideration would justify the omission of parts of the chapter on Useful Data.

The chapter on appraisal of buildings is premised as follows: "By the use of the data in this chapter it is easy to estimate the cost to reproduce almost any building constructed since 1890 of which the original cost is known." The limitation as to the original cost confines the use of these appraisal data to a comparatively small proportion of the buildings of which an appraisal is required. In this chapter the author presents a series of curves of index figures covering the variations of cost before and after the year 1914. These index figures relate to the following types: frame passenger stations; brick passenger stations; modern office buildings; frame shop buildings; brick shop buildings with wood framing; brick shop buildings with steel framing; pier shed with wood framing; pier sheds with steel framing; reinforced concrete warehouses.

MEMORIAL

Ambrose Vincent Powell

Past President, Western Society of Engineers

ON December 5, 1924, this Society and the engineering profession lost by death one of its most highly valued members, Ambrose Vincent Powell. For forty-three years, Mr. Powell was an active member of the Society; the records show that his interest in its welfare was a real and live one. He was treasurer of the Society from January 4, 1887 to January 3, 1888 when the holding of that office called for personal sacrifice and effort. In 1898, he was Vice President, and President of the Society in 1900. He contributed freely to the technical activities of the Society. His paper on Dry Docks appeared as the first paper in Volume 1 of the Journal of the Western Society of Engineers.

Ambrose Vincent Powell was born May 4, 1847, in Laurens, Otsego County, New York, and was the only child of Col. George W. and Mary (Dunbar) Powell.

He attended the Cooperstown (New York) Seminary, and later went to Rensselaer Polytechnic Institute at Troy, New York, from which he graduated in 1868 with the degree of Civil Engineer.

In 1869 Mr. Powell married Mary Alice Kellogg of Troy, New York, who died in 1898. In 1905, he married Hannah Belle Clark, who survives him.

As with many Civil Engineers of that period, his early work was with railroads. In the first decade following his graduation, he was successively: Assistant Engineer of the Oil Creek and Allegheny River R. R., Chief Engineer of the Michigan and Ohio R. R. and Engineer for the Receiver of the Chicago and Lake Huron R. R.

In 1880, he was Assistant Chief Engineer of the Chicago and Grand Trunk R. R., and had charge of its extension into Chicago. Following this work, he was with the Chicago and Western Indiana R. R. for a time. In 1882, he became the engineer for the South Chicago Dock Company, and in 1884 Engineer and Superintendent for the Calumet and Chicago Canal and Dock Company in charge of extensive improvements in and around South Chicago. He was Engineer and Superintendent of Public Works for the village of Hyde Park from 1886 to 1889, in which year the village was annexed to the City of Chicago.

After 1889 he devoted himself to private practice, specializing in coal unloading and storage plants, gas holders, harbor and dock improvements and construction, and land reclamation. He designed and constructed dry docks for the principal ship-building companies on the Great Lakes at Buffalo, Toledo,

AMBROSE VINCENT POWELL
Born May 4, 1847, Died Dec. 5, 1924

This classification is not very comprehensive, leaning heavily toward railroad and industrial structures. Even the office building appears to be more of a railroad type than of the usual commercial type.

The data given are in usable form so that within the limitations imposed, the approximate values can be determined. There are included in the chapter, however, many pages of detailed computations which were used in arriving at the index figures and which appears to be of very little value.

This book has been examined with a great deal of interest on account of the difficulties involved in treating this subject. The data given apparently are well founded and have been collected from reliable sources not generally available. The discussion is clear and the limiting conditions definitely set out, so that the book can be used with confidence.

—H. J. B.

Ashtabula, Chicago, Superior and Port Arthur, and was the first to use a concrete portal for a dry dock. Mr. Powell was a successful engineer, not alone on account of a good technical training, but also that rare natural ability that makes the more than ordinarily successful engineer. He was a keen observer, which, together with his logical thinking, resulted in a sound engineering judgment. He was a useful citizen, ever interested in the betterment of the community of which he was a part. For many years he was President of the Hyde Park Improvement Association, a voluntary organization which interested itself in the welfare of that part of the city. With all he was a man who had and retained a large circle of friends.

Mr. Powell was a member of the Western Society of Engineers, the American Society of Civil Engineers, the Calumet Country Club, and for many years of the Engineers' Club and Union League Club of Chicago.

(Signed) C. F. LOWETH,
J. W. ALVORD,
B. E. GRANT.

APPLICATIONS FOR MEMBERSHIP

Members of the Society can be of great service if they will make a practice of examining the list of applicants published herewith and promptly notifying the Membership Committee or the Secretary regarding the qualifications of any of those whose names appear on the list. The Society desires to extend its membership and receive those engineers who have the proper qualifications and wish to participate in its activities. The following applications have been received since last report:

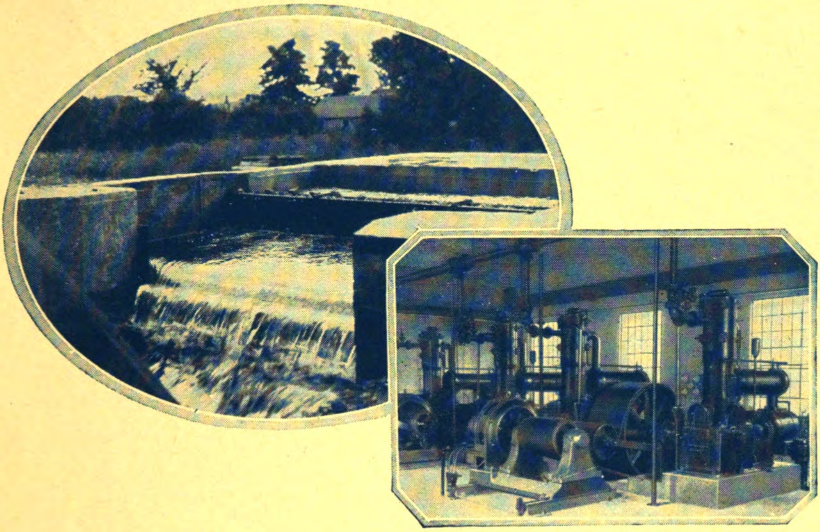
No.	Name	Address
133—1925	J. A. McFadden	416 Maryland St., Winnipeg, Canada
134	C. J. Quinn (Transfer)	3247 S. Michigan Ave., Chicago, Ill.
135	John M. Paver (Transfer)	1124 Judson Ave., Evanston, Ill.
136	H. B. Knudsen (Transfer)	118 E. 26th St., Chicago, Ill.
137	Ollie O. Kempf	3335 S. Michigan Ave., Chicago, Ill.
138	Wilford A. Marks	3335 S. Michigan Ave., Chicago, Ill.
139	Frederick M. Poole (Transfer)	1600 S. 4th Ave., Maywood, Ill.
140	Robert E. Lee (Transfer)	Box 152, Abingdon, Va.
141	Hilford G. Nelson	4455 Grand Blvd., Chicago, Ill.
142	James V. Miller (Transfer)	Box 163, Southampton, N. Y.
143	Richard B. Campbell (Transfer)	426 Arlington Pl., Chicago, Ill.
144	Robert E. Andrus (Transfer)	Box 174, Oak Park, Ill.
145	George A. Kain, Jr. (Transfer)	938 Ontario St., Oak Park, Ill.
146	Roland E. Koepp (Transfer)	R. F. D. No. 2, Box 117, New Braunfels, Texas
147	Carl W. Johnson (Transfer)	5054 W. Patterson Ave., Chicago, Ill.
148	Leonard Z. Plebanek (Transfer)	2019 Willow St., Chicago, Ill.
149	Harry Solomon (Transfer)	4829 N. Springfield Ave., Chicago, Ill.
150	William A. Gurtler	5718 S. Laflin St., Chicago, Ill.
151	Samuel Lilienthal (Transfer)	64 W. Randolph St., Chicago, Ill.
152	Charles W. Kramlich (Transfer)	531 11th Ave., Wauwatosa, Wis.
153	Lewis C. Halpin (Transfer)	Box 252, Glens Falls,, N. Y.
154	Arthur H. Brewer (Transfer)	1712 Juneway Terrace, Chicago, Ill.
155	Girard Nardone (Transfer)	3 Pleasant St., Westerly, R. I.
156	Leo Wolinsky	400 S. Laramie Ave., Chicago, Ill.
157	Abe J. Abrams	1648 S. St. Louis Ave., Chicago, Ill.

158	Edwin G. Slone	400 S. College St., Angola, Ind.
159	E. L. Fetcher (Transfer)	124 Hill St., Bucyrus, Ohio
160	Fred V. Johnson	718 Wisconsin Ave., Oak Park, Ill.
161	Samuel Friedman, (Trans.)	362 E. 26th St., Chicago, Ill.
162	Walter O. Moros	405 W. Gilmore St., Angola, Ind.
163	Earl J. Reeder	168 N. Michigan Ave., National Safety Council, Chicago.
164	Adelbert J. Bray, (Trans.)	Willow Springs, Mo.
165	George F. Long	1151 Addison Ave., Chicago, Ill.

NEW MEMBERS

The following were elected to membership in the grade shown by the Board of Direction at its meeting held June 22, 1925:

No.	Name	Address	Grade
89	Walter A. Himmelreicher	3109 N. Kimball Ave., Chicago, Ill.	Associate
90	S. M. Quinn	care Hotel Hayes, 64th St. and University, Chicago	Member
97	Fred M. Lyon	836 S. Michigan Ave., Chicago, Ill.	Affiliate
98	Edward Mundt (Transfer)	Lloyd, Montana	Junior
99	Henry T. Fisher	6127 Woodlawn Ave., Chicago	Associate
101	A. A. Sommerfield	401 Dowie Bldg., Chicago, Ill.	Member
105	Alfred G. Schutt	826 N. Ridgeland Ave., Oak Park, Ill.	Member
106	Carroll E. Robb, (Trans.)	168 N. Michigan Ave., Chicago	Junior
107	H. C. Friedman, (Trans.)	2241 Clifton Ave., Chicago, Ill.	Junior
108	Robt. K. Tullis (Transfer)	604 Daniels St., Toronto, Ohio	Junior
110	Charles J. Hageman (Transfer)	Newark, Delaware	Junior
111	Orlando C. Kohli, (Trans.)	923 N. Main St., Lima, Ohio	Junior
112	B. J. Rauchfleisch, (Trans.)	1837 W. Monroe St., Chicago	Junior
115	Mack G. Burkey, (Trans.)	4408 Lake Park Ave., Chicago	Junior
116	Guy E. Soper (Transfer)	Orland, Maine	Junior
117	Jerome H. Linden, (Trans.)	7724 S. Morgan St., Chicago	Junior
118	Glenn N. Romine, (Trans.)	New Boston, Michigan	Junior
119	H. N. Genkinger, (Trans.)	747 Hinman Ave., Evanston, Ill.	Junior
120	George F. Weinheimer, Jr.	4108 Grenshaw St., Chicago, Ill.	Student
121	Robert A. Granger (Transfer)	319 W. Ohio St., Chicago, Ill.	Junior
122	C. H. Langworthy (Transfer)	203 Embassy Apts., Portland, Ore.	Junior
124	Harold E. Tabbert (Transfer)	Hobart, Indiana	Junior
125	Theophilus Schmid, Jr. (Transfer)	10856 S. Wabash Ave., Chicago	Junior
126	Willard L. Alford (Transfer)	3247 S. Michigan Ave., Chicago	Junior
130	Harry Bernstein, (Trans.)	3539 Flournoy St., Chicago, Ill.	Junior
132	Morris D. Krausman	6006 S. Halsted St., Chicago	Junior
76	Ray M. Schmitter	2339 S. 50th Ave., Cicero, Ill.	Associate
91	Fred Weber (Transfer)	149 Broadway, New York City	Associate
92	Ralph A. Hibner	3926 N. St. Louis Ave., Chicago, Ill.	Junior
93	George E. Stevens (Transfer)	15 Anderson St., New Rochelle, N. Y.	Assoc.
94	Harold J. McCreary	3210 Arthington St., Chicago, Ill.	Associate
95	John A. Whitaker	311 S. Ridgeland Ave., Oak Park, Ill.	Assoc.
96	Burr J. French	5512 Flournoy St., Chicago, Ill.	Member
100	Lester I. Moore	3444 Wenonah Ave., Berwyn, Ill.	Associate
102	Kenneth F. Whitcomb	5616 N. Karlov Ave., Chicago, Ill.	Associate
103	Richard H. Tobin	5903 Eggleston Ave., Chicago, Ill.	Member
104	Lyman L. Browne	414 N. Stone Ave., La Grange, Ill.	Member
109	Chester R. Andrzelczyk (Transfer)	851 N. Ashland Ave., Chicago, Ill.	Associate
113	Arthur H. Swanson	209 S. Catherine Ave., La Grange, Ill.	Assoc.
114	Jack Rich (Transfer)	6122 N. Paulina St., Chicago, Ill.	Junior
131	Bernard E. Lindstrom	467 S. 4th St., Aurora, Ill.	Affiliate



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JOURNAL OF THE
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Volume XXX AUGUST, 1925 Number 8

Summer Excursion Planned

EXCURSIONS to points of engineering interest are one of the features of the Society's work that our members seem to enjoy the most. During the summer vacation we have not attempted to hold any of these excursions, but there is an opportunity presented now which should not be overlooked.

Our Excursion Committee has had in mind for some time an inspection trip to the North Side Sewage Treatment Plant of the Sanitary District of Chicago. It has been the idea to inspect this plant at the most opportune time. We now learn that if we are to see the plant at the time when it will be the most interesting to engineers, we will have to do so within the next two or three weeks. By that time most of the concreting will be completed ready for the installation of the machinery.

The concrete mixing and placing plant is one of the most interesting parts of the construction of this project. The contractors John Griffiths & Sons Co., have erected a rather unusual cable way. It consists of two towers mounted on railroad trucks, and operating on tracks paralleling the sides of the plant. The distance between the towers is about 600 ft. which is spanned by a cable carrying a bucket holding 7 yards of concrete. The towers are propelled by electric motors and are connected together, so that they operate in unison. The whole apparatus travels the entire length of the plant and the concrete may be deposited at any desired point.

At the time of the Excursion over the Niles Center Extension last year, we had an opportunity to get a birdseye view of the construction, then in progress. One battery of tanks was completed and partly roofed over. The concrete was being poured for the second battery and ground was being prepared for the erection of the forms for the third. Those who were on that excursion were impressed by the size of the project.

The transportation for this excursion will be very satisfactory. The new Niles Center Extension of the Chicago Rapid Transit Lines, lies along the north side of the treatment works and there is a station nearby. In order to get there it will only be necessary to take a Northwestern elevated train to Howard Ave. and transfer to the Niles Center branch. We are assured by the Engineers of the Sanitary District that there will be a goodly number of representatives from their department present to conduct our members over the works in groups, and explain everything to them fully as they go along.

It will be about a year before the plant is finally placed in operation, at which time we want to go out again, and see how it works. The total cost of the project will be in the neighborhood of twenty million dollars, about three-fourths of which will be spent on sewers and the remainder for the construction of the sewage plant itself. This plant will be what is known as the activated sludge process which provides for practically complete removal of all impurities from the water. The sludge can be taken out and dried and finds a ready market for fertilizer in some places. Present plans for this plant do not provide for drying the sludge which will be pumped to a large lagoon several miles to the west.

Fraser S. Keith, has resigned as Secretary of the Engineering Institute of Canada, after eight years service in that capacity. His resignation was tendered January 1, 1925, but his services were retained by the Institute in a consulting capacity until the end of June. Upon his retirement from this position he was presented with a beautiful silver tray 18 inches in diameter, upon which were engraved the signatures of all those who have served on the council of the Institute, since he had been its Secretary. Mr. Keith resigned the secretaryship to assume an important position with the Shawinigan Water and Power Company, Montreal, as manager of the department of development.

Office Equipment Secured

At a meeting of our Executive Committee a few days ago the Secretary happened to mention the fact that the Society was badly in need of some additional dictating machines for use in the office.

One of the members of the Board immediately spoke up and said that his company had some Edison Dictating Machines in its office which were not being used and he would be glad to turn them over to the Society together with a machine for shaving the cylinders. As a result, the Society's office equipment has been increased by the addition of a complete dictating machine, a transcriber and a cylinder shaving machine, all of which have been put into immediate and effective use. The Society is grateful for the loan of this equipment.

Now if some of our members can supply us with, or know where we can get, an addressograph that is in good operating condition, our mechanical equipment will be in pretty good shape. Our addressograph has done faithful service for many years, but it has been so much used that it requires constant attention to keep it in repair. We are working in constant fear that it will break down in the midst of a mailing and cause some serious delay. We could also use a folding machine.

It should be understood that the Society is not begging for a donation, but the fact remains that if some money can be saved on the purchase of an addressograph, it will mean just that much more to go into postage or printing or new books for the library, or service to the members. Any suggestions will be welcome.

A New Advertising Policy Determined

We have secured the services of D. T. Eastman, an expert on advertising and at present Secretary and Treasurer of the Engineering Advertisers Association of Chicago, to handle the advertising in the Journal. Mr. Eastman will undertake to build up the Advertising Section of our publication, which he recognizes as a high class medium for industrial advertising.

It will be necessary to make an increase in the rates which will bring our Journal up on a par with technical magazines, but yet will not approach advertising rates charged by some of the other engineering societies.

Our Board of Direction in adopting a plan to increase the amount of advertising in the Journal, believes that some added revenue may be obtained which will result in further improvement of the Journal. This will also release funds of the Society to be devoted to other important phases of its work, which have not been given full support heretofore, because of the large expense of publishing a Journal such as ours.

Where Are These Men?

In our efforts to keep the mailing list of the Society up to date it is necessary for us to publish a list of names of our members to whom the Post Office has been unable to deliver mail at the last address given in our records. Mail has been returned from each of the following whose last address is shown in this list. If any of our members knows the whereabouts of any of these gentlemen, we would consider it a great favor, if he would notify us how we may reach him.

William Bernmann, 5144 Sheridan Rd., Chicago.

Samuel Deutsch, 4454 N. Albany Ave., Chicago.

M. H. Genena, 509 S. 6th St., Champaign, Ill.

J. A. Dyer, C. & N. W. Pass Sta., Mason City, Ia.

W. H. Schott, 9 E. 46th St., New York City.

Albert Krattinger, General Delivery, Newark, N. J.

J. R. Culver, 3819 Janssen Ave., Chicago.

Frank E. Stewart, A. W. S. E. Sales Engineer, Sinclair Refining Co., Chicago has been assigned to the Atlanta, Ga. district of that Company as Assistant Sales Manager. He is to assume his new duties in Atlanta, August 1. Mr. Stewart has been in the Chicago office selling lubricating oils in the Industrial Department.

New Union Station Opened

Chicago's New Union Station was dedicated amid appropriate ceremonies, July 23, in the presence of an invited company of about 250 prominent railroad executives, engineers and public officials.

The party assembled at the main entrance to the station on Canal Street, where it was met by the officers and engineering staff of the Chicago Union Station Co. and conducted on a short tour of inspection through the Station and the Mail Terminal building. The route led through the main waiting room to the north driveway, and down through the baggage room into the connecting tunnel leading to the new Mail Terminal building. Here the automatic sorting machine which delivers bags of mail to cars on the same principle as the cash carriers used in department stores, was demonstrated. Returning to the train concourse by way of the train sheds, the party returned to the main waiting room by way of the passage under Canal Street where the ticket offices are located and passed on into the room in the basement which will be occupied by the cafeteria. This room was beautifully decorated with flowers and ferns and a most excellent luncheon was served.

After the guests had finished eating, Samuel Rea, President, Pennsylvania Railroad Company and President Chicago Union Station Company, delivered a short address of welcome. He pointed out that it was interesting coincidence that this station should be finished during the year when the world is celebrating the 100th anniversary of the building of the first railroad. Although that event occurred in England most of the development of railroad transportation has taken place in the United States which leads the rest of the world by a wide margin. Chicago is the center of this vast system and is known as the world's greatest railroad center.

The new Chicago Union Station in its massive dignity and solidity symbolizes the character of the American transportation system. It has another significance in that it serves to direct public attention to the enormous amount of capital that is required by the transportation companies in order to permit them to give the service required by the public. It is well known that the ability to earn a return on an investment, depends upon the ability to operate at a profit, which can only be done on adequate rates. The public is coming to realize that if the railroads are unfairly treated the public will suffer.

Mr. Rea pointed out that this station is built to aid the flow of commerce and is dedicated to those purposes which will serve the public interest. The acceptance of its facilities by the public signifies an obligation on the part of the public to protect the interests of the investors whose capital has made the station possible. He was pleased to say that the present appears to be a time of happy relations between the public and the railroads which are strenuously endeavoring to give adequate service to the public. This occasion he remarked, was one in which those who have labored in building the station might take pardonable pride.

Mr. Rea called upon Hon. William E. Dever, Mayor of Chicago, to say a few words. Mayor Dever on behalf of the City of Chicago and its public officials expressed his appreciation and the City's pride in its new station. He said that in his opinion a station such as this one, signifies that the greatest public utility can best succeed by rendering desired service to the public. He stated that there has been some softening of public opinion toward the railroads, due to the realization on the part of the operators that the public will appreciate adequate service.

Remarking that the completion of this station might be said to be the finest thing that has yet been done in Chicago, the Mayor said that it's completion ought to point the way to the other railroads to a way to solve their own problems. As is well known, the greatest thing that is now retarding the development of the City, is the terminal situation south of Van Buren Street. The City has a large interest in this matter and has as its principal objective the opening of streets and building a terminal. The matter of straightening the river is merely an incidental feature of the main program. He

made a plea for the interested railroads to get together and compose their differences and hoped that the same spirit of co-operation, would be evidenced as has been seen in building the Union Station. He further, said that the City would not attempt to dictate how the problem should be solved, but would insist on opening streets at the earliest possible moment. Since the future hopes of the City of Chicago are so intimately tied up with its transportation facilities, the Mayor insisted that there must be a friendly spirit of co-operation, which he indicated was the attitude of the City administration.

These two addresses closed the formal part of the day's program.

The Western Society of Engineers is interested in the station project from several different angles. A considerable number of its members have been engaged in the work of designing and building the station, some of them from its very inception. Two very important and interesting meetings have been devoted to engineering problems in connection with the Station and it is now planned to present a meeting or series of meetings in the early part of next fall, which will cover all of the different parts of this project, in rather complete detail. There will probably be papers describing the general plan and studies made to determine the best way of operating large passenger stations. There will be other papers covering the mechanical features, such as heating and ventilating, while still others will be devoted to the electrical apparatus, lighting, signaling, etc. The study of the tracks and train sheds alone is large enough to devote a whole evening to it, as is also that of the facilities for handling mail, baggage and express. Our Program Committee is now actively considering the best way to present all this mass of information for the benefit of the members of the Society.

An engineering project in Chicago in which the Society has more or less of an interest, is the 23rd St., Viaduct just completed, as a part of the development along the lake front on the south side of Chicago.

Avery Brundage, M. W. S. E. was General Contractor on the construction of this bridge. Condron & Post were Consulting Engineers who drew the designs for it. Both the members of this firm and also a number of the men whom they employ are members of this Society. The entire south shore development is under the direction of the South Park Commissioners of which Edward J. Kelly, M. W. S. E. is President. Linn White also a member of the Society is Chief Engineer and a number of the other engineers engaged in different parts of the project are members.

T. L. Condron read a paper before the Society in February, 1923, describing the new viaduct which is the connecting link that opens up another avenue of travel from the business district of the city toward the South.

More About the Engineman

In the July Journal we commented upon the adoption of the word "engineman" by certain organizations when referring to certain positions, that are not really engineering.

One of our members comments on that article as follows:

July 27, 1925.

Mr. Edgar S. Nethercut,
Secretary, Western Society of Engineers,
1735 Monadnock Block,
Chicago, Illinois.

Dear Mr. Nethercut:

On page 107 of the July Journal I note mention of the desirability of using the term "engineman" for certain operating positions that do not come within the professional engineering field as we understand it.

It has occurred to me that it might be interesting to you to know that my firm, in the course of many years of work in the public service, has consistently used and advocated the use of this term. We have been instrumental in having it adopted by the Canadian Government, the United States Government, and by a number of the largest cities. In a number of instances, such as in Detroit recently, we have failed in our effort to get the authorities to accept this change because of the opposition of the stationary Engineers' organizations.

We believe that there is a real opportunity for the Western Society and for

other societies to do something in this connection. They ought to address budget authorities and civil service commissions in the matter. Perhaps some national medium ought to be used. You will find that the enginemen themselves are exceedingly alert on the other side of this question.

Yours sincerely,
(Signed) E. O. GRIFFENHAGEN,
Director, Griffenhagen & Associates, Ltd.

We would like to hear some more comments on this same idea.

Public Affairs Policy

The Chicago Evening Post publishes an editorial in its issue of July 15 which is of sufficient interest to the members of the Society, that it is worth repeating here. The editorial is as follows:

RETAIN THE PURIFICATION FEATURE

"In his latest proposal for the meterization of the Chicago water system, which is compulsory under the war department ruling in the Lake Michigan water diversion case, Commissioner Sprague offers a 2½ cent reduction below that first proposal for the initial business water rate and retention of the discount of 15 per cent which is now offered for prompt payment of the water bill. To offset this loss in revenue, he asserts, the proposal to install filtration plants for the city water supply will have to be abandoned for at least ten years.

"This is indeed unfortunate and in direct variance with the findings of prominent engineers. Practically every study of Chicago's water supply and sewage problems has taken the installation of modern filtration plants, at the water intakes as an accepted necessity. In his paper at the mid-winter convocation of the Western Society of Engineers, City Engineer John Ericson asserted that: 'Health officers and sanitary engineers generally advocate filtration as the best and most desirable method of purifying and clarifying water.'

"After reviewing the early efforts, including his own reports, to obtain a filtration system, he continued:

"'Arthur E. Gorman, chief sanitary engineer, Chicago health department, in a recent article states that the water supply of Chicago is becoming more and more potentially dangerous and that the increasing quantities of chlorine required for disinfecting purposes will render it quite objectionable for drinking purposes.

"'Filtration of the Chicago water supply is therefore rapidly becoming a very important matter.'

"The saving in money through the installation of meters and the elimination of preventable leakage and wastage, he estimated, 'will be sufficient to defray all necessary expenses for operation and needed additions, as well as for the construction and operation of filter plants, and still permit a lowering of rates or leave a considerable surplus.'

"So impressed was the Western Society of Engineers by his and other papers dealing with the problem that the formal report of the committee in charge of the convocation asserted that 'filtration is the primary line of defense against water-borne disease. Filtration will eliminate the objectionable taste in the water due to the present necessity for heavy chlorine dosage, and will provide a clear, sparkling water at all times.

"The commercial users of the city's water have no interest in its purity and will probably welcome Commissioner Sprague's suggestion that the filtration program be postponed. Those who drink it, however, should insist that any meterization ordinance carries full provision for a modern filtration system."

Again on July 24 the same paper takes up the subject editorially as follows:

METERING IS DEFERRED

"Action on the water meter ordinance has been deferred until October 28, after a council session which nearly spelled defeat for the measure. As a result, the Secretary of War may revoke the permit for the diversion of Lake Michigan water through the drainage canal and create a health menace which has been too often discussed to need elaboration here.

"Apparently some such drastic threat is needed to bring the aldermen, or their constituents, to their senses. Chicago's water wastage is tremendous and largely to blame for the hot weather conditions which leave many third-story flats as waterless as if the farmyard pump, and not the modern faucet, were still in use. Water metering would eliminate this, or

at least make the wasters pay for their carelessness, but twenty-seven of the aldermen will have none of it, federal threats or no federal threats. An "aye" vote, they insist, means retirement at the next election.

"A campaign of education is apparently a necessity. As a preliminary, it might be well to have an impartial committee appointed, say, by the Western Society of Engineers, make a thorough investigation of the reasonableness of the rates and charges in the proposed ordinance, and the probable annual cost for domestic users. The society has made many valuable studies of Chicago conditions in the past; it may be glad to serve in a similar capacity in this controversy.

"So much has been said that is conflicting regarding the cost of water under the meter system that a report of this nature becomes an essential if the voters are to understand the situation."

The suggestion contained in this editorial is an evidence of the general re- tation of the Society on matters of engineering interest. The fact that it's opinion is sought on such a question as that of metering the water supply of the city is in itself a challenge to the Society. Obviously it has an obligation to perform in this matter. The Post suggests that "it would be well to have an impartial committee appointed by the Western Society of Engineers to make a thorough investigation of the reasonableness of the rates and charges in the proposed ordinance, and the probable annual cost for domestic users."

The policy of the Society in establishing its Public Affairs Committee has been to review matters of public interest, having an engineering basis and co-ordinate the opinion of our members, in view of their large personal information and experience. Recommended policies are formulated as a result of these reviews.

We need a policy for the Society in matters of investigation requiring professional services on the part of the members. The Board of Direction will welcome suggestions from members as to how such important matters as the one illustrated in these editorials, might be handled.

A History of Railroads

Last winter the Young Men's Forum had the opportunity of spending a splendid evening with Mr. C. Vernier, Chief Transmission and Distribution Engineer of the Newcastle Electric Supply Co., Newcastle, England. Mr. Vernier seemed to enjoy coming to the rooms of the Western Society and attended a great many meetings. We came to know him rather well during the time that he was in Chicago, where he was supervising the installation of some new high-voltage underground cable.

Mr. Vernier has just sent us a copy of the Railway Centenary Supplement to the Northern Echo, a newspaper published in Darlington, England, the principal office of the first steam railway in the world. This supplement is a magazine of 82 pages and lithographed cover. It is profusely illustrated with photographs of early locomotives, cars, etc., and filled with interesting articles, describing the origin of railways, a description of early equipment, formation of the first railroad company, construction of the line, etc. Unfortunately it is printed on ordinary newsprint paper and many of the illustrations are not clear. This is a valuable compilation of historical matter and it is to be hoped that it will be recorded in more permanent form.

The copy of this supplement has bee placed in the Library and is well worth anyone's time to read it over, just from its historical interest.

We are grateful to Mr. Vernier for his thoughtfulness, in sending this interesting publication to us.

New Books

621.1836
W927m

Mechanical stokers including the theory of combustion of coal.

By J. G. Worker and T. A. Peebles. New York, McGraw, 1922. 258p. Illus., tables, diags.

After a brief history of the stoker, the authors discuss the kinds of coal and their combustion characteristics, the factors affecting selection of stoker equipment, and stoker installation. A chapter on stoker equipment of modern steam power stations shows the practical application of the device.

E381ig

History of electric light.

By Henry Schroeder. Washington, Smithsonian Institution, 1923. 95p. Illus. (Smithsonian Msc. Collec. v. 76 No. 2.)

Begins with early records of electricity and magnetism; discusses the Leyden jar and Volta's battery; treats of dynamo development; and takes up in detail various arc and incandescent lamps showing the evolution from De Moleyn's incandescent lamp to the present day tungsten lamps

629.11
L341e

The electric motor truck.

By Edward E. La Schum. New York, U. P. C. Book Co., 1924. 307p. Illus., tables, diags.

Technical descriptions of kinds and parts of electric motor trucks designed to aid the prospective owner in selection and the prospective operator in a more thorough knowledge of the mechanism with which he will deal. A chapter on cost accounting methods and forms is very practical.

666.4
L897b2

Burning clay wares.

By Ellis Lovejoy. 2d ed. Indianapolis, Randall, n.d. 324p. Illus., tables, diags.

A practical treatise on clay and its behavior in the burning process. Kilns, furnaces and stacks are discussed; and there are notes on the setting problems of various clay products, such as brick, tile, terra cotta, pottery, etc.

662.6
B129a

American fuels.

By R. F. Bacon and W. A. Hamor with the collaboration of specialists. New York, McGraw 1922. 2v. Illus., tables, diags.

Treats of the technology of coal, coke, briquetted fuels, finely divided fuel, oil, colloidal fuel, the various kinds of gas fuels, and ends with an economic consideration of fuel conservation and complete utilization. Aims to provide the engineer with such information as will assist him in deciding upon the most suitable fuel to use or the changes to make in the utilization of fuel or of heat in order to get the highest efficiency in plant operation.

331.86
H322p

Public employment offices: their purpose, structure and methods.

By S. M. Harrison and others. New York, Russell Sage Foundation, 1924. 685p. Plates, tables, diags.

An excellent treatise by competent sociologists and economists resulting from actual contact with employment problems throughout the United States. Includes constructive suggestions for the organization and regulation of such offices.

628.1
T944p3

Public water-supplies: requirements, resources and the construction of works.

By F. E. Turneaure and H. L. Russell. Chap. XXVI on Pumping machinery by D. W. Mead; Chaps. VIII, IX, X, on Quality of water-supplies revised by C. M. Baker. 3d ed. rev. New York, Wiley, 1924. 766p. Illus., tables, diags.

Especial attention has been given in this new edition to the subjects of consumption of water, stream flow, filtration, chlorination, the quality of water-supplies, reinforced concrete in waterworks construction and pumping machinery. The general arrangement of material remains the same. The bibliographies have been revised and brought up-to-date.

For those unfamiliar with earlier editions the material divides itself into two parts: (1) the quantity of water required; sources of supply; quality of water-supplies; (2) the construction of waterworks—(a) for the collection of water; (b) for the purification of water; (c) for the distribution of water.

Central and district heating. Possibilities of application in Canada.

By F. A. Combe. Ottawa, Canada, 1924. 79p. Tables, maps, diags. (Canada. Dominion Fuel Board. No. 3.)

The results of an investigation carried out to determine the present status and practice of district heating in other countries, particularly in the United States and a survey made of conditions obtaining in Canada, to determine the possibilities of the application of this form of heating in the different towns and cities of the Dominion. Contains an excellent review of American conditions and has a bibliography of material from 1914 to date on this subject.

622.06
M678bt
v.7, No.3

Mechanical underground loading in metal Mines.

By Charles E. Van Borneveld. Rolla, Missouri, May, 1924.

Published as co-operative work between the U. S. Bureau of Mines, Mississippi Valley Station, and the Missouri School of Mines and Metallurgy.

Contents: Part 1. General consideration of the advantages of mechanical loading, use of electric locomotives, etc. Part 2. Description of mechanical shovels Part 3. Scraping machinery and methods. Part 4. Description of mechanical shovel installations, loading problems in lead and zinc districts, cost and operating data, and time studies.

The power resources of the Commonwealth of Australia and the mandated territory of New Guinea.

By the Institution of Engineers, Australia. Report to the World Power Conference, London, 1924. Sydney, Kent, 1924. 131p. Plates, tables, maps, diags.

Authoritative and interesting accounts of water power, coal, and liquid fuel resources of Australia with a discussion of existing power supplies.

Munday's earning power of railroads.

By Floyd W. Mundy. New York, Oliphant, 1924. 19th issue. 490 p. Tables.

Statistics based on official annual railroad reports regarding earnings, mileage, capitalization, tonnage, investments, physical and financial condition, etc.

Highway transportation costs.

By T. R. Agg and H. S. Carter. Ames, Iowa State College, 1924. 31p. Diags. (Iowa State College. Engineering Experiment Station. Bulletin 69.)

The outgrowth of a prolonged study of the various factors affecting vehicle operating cost, such as the rolling resistance and relation between road types, fuel consumption, and general operating costs of vehicles. Includes some investigations of the annual cost of highway maintenance, and of the economic life and life tonnage of roadway surfaces.

Additions to the Library

Chicago. City Council. Building ordinances with amendments up to and including July 1st, 1924. 1924.

American Society for Testing Materials. Proceedings. v. 24. 1924. 2v. Part 1. Committee reports. Part 2. Technical papers.

Humphrey, C. J. and Miles, L. E. Dry-rot in buildings and stored construction materials and how to combat it. 1925.

Insull, Samuel. Public utilities in modern life. 1924.

Society of Automotive Engineers. Research Dept. A bibliography relating principally to items associated with the problems of riding qualities. 1925.

American Institute of Steel Construction. Steel construction. 1924.

Thompson, Slason, comp. Railway statistics of the U. S. of America for 1923. 1924.

U. S. Congress. House. Water terminals and transfer facilities. 1922.

U. S. Army. Engineers corps. Shore control and port administration. 1923.

International Electrotechnical Commission. U. S. National Committee. Report of the July 1924 London meeting of the Advisory Committees of the I. E. C. 1924. Reports on progress of rating, nomenclature, symbols, etc. for electrical machinery.

Institution of Water Engineers. Transactions. v. 29. 1924.

Institution of Engineers, Australia. Transactions. v. 3. 1922.

New York (City) Board of estimate and apportionment. Report of chief engineer. 1923.

Missouri. Bureau of geology and mines. Biennial report. 1925.

Missouri. Bureau of geology and mines. Reports. 2d series. v. 18. 1924. Structural reconnaissance of the Mississippi Valley area from Old Monroe, Missouri to Nauvoo, Illinois.

Illinois. State Geological Survey. Cooperative mining series. Bulletin 28. 1925. Preliminary report on coal stripping possibilities in Illinois.

Illinois. State Geological Survey. Report of investigations. No. 5. 1925. Structure of Herrin coal seam (No. 6) near DuQuoin.

Wisconsin. Geological Survey. Bulletin 57, Part 2. 1924. Phytoplankton of the inland lakes of Wisconsin.

William Wurth, M. W. S. E., presented the Library with four volumes of the *General Electric Review* to help build up our set.

The Library needs war-year numbers of various periodicals to complete its files of bound reference material. If any of the members have such numbers stored away and not being used, it would be a matter of service to the Society to present them to the Library.

The following list is incomplete, but it contains the magazines needed most urgently:

Gas Age v. 42, July-December 1918.

Gas Age v. 44, July-December 1919.

Iron Trade Review v. 60-63, January, 1917, December, 1918.

American Architect v. 110, July-December, 1916.

American Architect v. 116, July-December, 1919.

Machinery v. 23 No. 5-12, January-August, 1917.

Machinery v. 24, No. 1-12, September, 1917, August, 1918.

Engineering and Mining Journal v. 103-105, January, 1917-June, 1918.

Mining and Scientific Press v. 112, January, 1916 to end of its existence as a separate magazine.

Other missing volumes in incomplete periodical sets are:

American Machinist v. 34-49, 1911-1918.

International Marine Engineering v. 21-23, 1916-1918.

Iron Age v. 52-64, 1893-1899.

Machinery v. 1-6, 8, 1894-1899, 1901.

We have just been advised of the sudden death of David R. Llewellyn, M. W. S. E. on May 25, 1925.

Mr. Llewellyn was at work as usual in Lassig Plant drawing room that day and was apparently in good health. At about nine o'clock that evening he went on an errand, to a store about two blocks from his home. A neighbor going along the street a short time later discovered the body on the sidewalk. A physician was called immediately but life had departed before the body was found, heart disease being the cause.

Mr. Llewellyn was a native of Sterling, Ill., and funeral services took place there on May 29th. He is survived by his wife, Mrs. Jessie Llewellyn of this city.

We did not know of Mr. Llewellyn's death until mail addressed to him was returned to us by the post office.

He was a foreman in the employ of the American Bridge Co. at the Lassig Plant and had been a member since December 3, 1919.

Francis John Llewellyn, M. W. S. E. died at Portland, Oregon, July 25. He was born in England, May 22, 1861 and at the age of 15 entered upon a five years apprenticeship to Ginson & Co., engine and machine builders at Leicester, England. In 1881 he became estimating draftsman and designer for the Midland Railway Carriage and Wagon Co., at Shrewsbury, England, which position he held until 1884. He then came to America and entered the employ of Gillette Herzog Mfg. Co., Structural Engineers of Minneapolis, Minn., in the capacity of Superintendent. In 1886 he became Vice President and Chief Engineer of that Company. He was President of the Koken Iron Works at St. Louis in 1900 and in 1901 was made Contracting Manager and Assistant to the President of the American Bridge Co. of New York, Western Division at Chicago. He became a member of the Western Society of Engineers, December 14, 1903 and retained his membership until May 31, 1925.

Mr. Llewellyn has been in Portland, Oregon since last November in an effort to recuperate his health.

APPLICATIONS FOR MEMBERSHIP

Members of the Society can be of great service if they will make a practice of examining the list of applicants published herewith and promptly notifying the Membership Committee or the Secretary regarding the qualifications of any of those whose names appear on the list. The Society desires to extend its membership and receive those engineers who have the proper qualifications and wish to participate in its activities. The following applications have been received since last report:

No.	Name	Address
166—1925	Harold J. Holmquest (Transfer)	220 S. Lotus Ave., Chicago.
167	George R. Herrmann	1122 N. La Salle St., Chicago.
168	Richard E. Ostland (Transfer)	3108 Oak Park Ave., Berwyn, Ill.
169	Everett Leibundguth	203 S. Main St., Downers Grove, Ill.
170	John N. Ostrum	547 W. Jackson Blvd., Room 1501, Chicago.
171	Fritz W. Wandschneider (Transfer)	311 N. Central Ave., Chicago.
172	Chas. S. Frink, Jr. (Transfer)	349 S. Weadock Ave., Saginaw, Mich.
173	George W. Swallow (Transfer)	814 Marquette Bldg., Chicago.
174	Albert P. Stein, (Trans.)	4636 N. Leavitt St., Chicago.
175	Benjamin F. Morrison (Transfer)	1521 E. 68th St., Chicago.
176	George D. Arachovitis (Transfer)	6122 Evans Ave., Chicago.

177	Philip H. Eichler, Jr. (Transfer)	31 McArthur Pl., Middle Village, L. I.
178	James W. Cohn	3718 Douglas Blvd., Chicago.
179	Lawrence L. Flint (Transfer)	Box 104, Sanborn, Ia.
180	Howard E. Norton (Transfer)	614 Central Ave., Wilmette, Ill.
181	Edward F. Webb (Transfer)	358 E. 70th Pl., Chicago.
182	Alvin W. Cockrell (Transfer)	5117 W. 24th St., Cicero, Ill.
183	Edward F. Weber (Transfer)	355 Anthony St., Glen Ellyn, Ill.
184	V. G. Burmistroff (Transfer)	% Meyer's Camp Bladgett, Highland Park, Ill.
185	C. F. McCandless (Transfer)	409 Walnut St., Three Rivers, Mich.
186	Alfred E. Rand, (Trans.)	Hummer Plow Works, Springfield, Ill.
187	Richard B. Berry, (Trans.)	7344 Drexel Ave., Chicago, Ill.
188	John E. McCauley (Transfer)	43 Latrobe Ave., Chicago.
189	William Siegle, (Trans.)	1810 Nebraska Ave., St. Louis, Mo.

NEW MEMBERS

The following were elected to membership in the grade shown by the Board of Direction at its meeting July 20, 1925:

No.	Name	Address	Grade
123—1925	E. Chris Mahnke, (Trans.)	1400 E. 53rd St., Chicago	Associate
128	Samuel A. Burger (Transfer)	5306 N. Winthrop Ave., Chicago	Junior
129	Michael Raphael, (Trans.)	621 Harrison St., Davenport, Ia.	Junior
133	J. A. McFadden	416 Maryland St., Winnipeg, Can.	Junior
134	C. J. Quinn, (Trans.)	3247 S. Michigan Ave., Chicago	Junior
135	John M. Paver, (Trans.)	1124 Judson Ave., Evanston, Ill.	Junior
138	Wilford A. Marks	3335 S. Michigan Ave., Chicago	Junior
139	Frederick M. Poole (Transfer)	1600 S. 4th Ave., Maywood, Ill.	Junior
140	Robert E. Lee, (Trans.)	Box 152, Abingdon, Va.	Junior
142	James V. Miller, (Trans.)	Box 163, Southampton, N. Y.	Junior
146	Roland E. Koepp, (Trans.)	Box 117, New Braunfels, Texas	Junior
148	Leonard Z. Plebanek (Transfer)	2019 Willow St., Chicago	Junior
149	Harry Solomon, (Trans.)	4829 N. Springfield Ave., Chicago	Junior
152	Charles W. Kramlich (Transfer)	531 11th Ave., Wauwatosa, Wis.	Associate
156	Leo Wolinsky	400 S. Laramie Ave., Chicago	Junior
157	Abe J. Abrams	1648 S. St. Louis Ave., Chicago	Junior
160	Fred V. Johnson	718 Wisconsin Ave., Oak Park, Ill.	Member
164	Adelbert J. Bray, (Trans.)	Willow Springs, Mo.	Associate
165	George F. Long	1151 Addison Ave., Chicago	Junior
127	Edgar R. Safarik	1301 N. Parkside Ave., Chicago	Junior
136	H. B. Knudsen, (Trans.)	118 E. 26th St., Chicago	Associate
145	George A. Kain, Jr. (Transfer)	938 Ontario St., Oak Park, Ill.	Associate
150	William A. Gurtler	5718 S. Laflin St., Chicago	Associate
151	Samuel Lilienthal (Transfer)	64 W. Randolph St., Chicago	Associate
154	Arthur H. Brewer (Transfer)	1712 Juneway Terrace, Chicago	Associate
163	Earl J. Reeder	care of National Safety Council, 168 N. Michigan Ave., Chicago	Member

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SEPTEMBER, 1925

In this issue:

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JOURNAL OF THE
WESTERN SOCIETY OF ENGINEERS

Volume XXX SEPTEMBER, 1925 Number 9

Starts the New Year

This month is the beginning of the fifty-fifth year of the Western Society of Engineers technical programs. The indications at this time are that the program of continually increasing interest will be maintained.

In any Society made up of so many different interests as are represented in ours, there is likely to be a tendency on the part of some to attend only those meetings which pertain to their own particular specialty. This is a policy which the Western Society has always attempted to avoid and there are several good reasons for it. In the first place, any engineer can be assumed to be reasonably well informed on his special line of work. He becomes a better engineer by informing himself about some of the other branches of the profession. Sometimes it happens that a man attends only the meetings devoted to his specialty and soon becomes possessed of the idea that he knows as much or more than any of the speakers and as a result he becomes disgusted with the whole thing. On the other hand if he will attend some of the other meetings which are not too far removed from his line of work to be interesting he is certain to learn something that is of value to him.

In a program of such a wide variety as ours, it is certain that there is more than one meeting every month that appeals to each individual member of the Society. These meetings are offered for the benefit of the members. Whether they take advantage of them is a matter entirely for their own decision. The program for September as described in the following paragraphs is an example of the kind of papers that we are bringing before the members for their benefit.

Bridges in Grant Park

Grant Park in Chicago which is commonly referred to as Chicago's front yard is bisected in a north-and-south direction by the right of way of the Illinois Central R. R. which is crossed at frequent intervals by east-and-west streets. The design of the bridges to carry these streets over the railroad tracks presented a complicated problem which was explained and analyzed Monday, September 14 by C. R. Hoyt, Structural Engineer, South Park Commissioners.

In planning for the ultimate development of the Illinois Central facilities, it was necessary to provide for the possible operation of two levels of tracks from Randolph Street to 12th Street. It was necessary to limit the clearance between tracks to the absolute minimum and at the same time the overhead clearances where extremely shallow because of the relative street and railroad grades. An exhaustive investigation of all of the economic and construction features involved indicated that a continuous girder type of bridge was best adapted to meet this situation. Seven of these bridges have therefore been designed to be built over the Illinois Central tracks. This required development of comparatively new scheme of bridge construction which permitted the use of slender columns. Because of limited space between tracks, the foundation work was rather difficult.

Corrosion of Underground Structures

The next meeting will be September 21 at which time A. J. Fecht, Electrical Engineer formerly with William G. Woolfolk, Consulting Engineer, Chicago will present a paper on "Corrosion of Underground Structures." Nobody knows the total amount of damage that is caused in this country by corrosion both above ground and below. We have pretty well determined the methods to be used to prevent corrosion of all structures above ground, but the treatment of those that are buried in the earth is an entirely different matter. This has caused engineers a great deal of trouble, particu-

larly since it concerns such things as water mains, underground conduits and foundations.

Exhaustive investigaions have been conducted by the Bureau of Standards, at Washington and by consulting engineers and public utilities all over the country. They have disclosed that the corrosion may be divided into classes, namely, that caused by electrolysis and that due to chemical elements in the soil. Mr. Fecht was in charge of a large part of the work done by the Bureau of Standards and has been associated with Mr. Woolfolk in Chicago during many of his extensive investigations of corrosion in underground structures in this area. His paper analyzes the different causes of corrosion and how they may be distinguished and what measures may be taken to prevent it. This will be illustrated with a large number of lantern slides showing the damage done by corrosion and means adopted to prevent it. This paper is full of technical data which have not been published heretofore.

Chicago's New Union Station

September 28 will be the first of a series of three meetings to be devoted to the new Union Station just opened in Chicago. This subject is of such importance and covers so much material that it would be impossible to present it in an adequate manner in one evening. It has therefore been subdivided into three sections, which will be presented on successive Monday evenings.

The first meeting on the 28th will be devoted largely to a general consideration of the entire terminal project. J. D'-Esposito, M. W. S. E. Chief Engineer, Chicago Union Terminal Co. will be the principal speaker. Mr. D'Esposito has been at the head of the engineering of this project from its beginning. He finds that the literature of engineering contains very little about the fundamentals of terminal planning. His own investigations will be described in this paper with an analysis of the factors entering into decisions reached in designing the new station in Chicago, which is one of the largest in the world. In many respects it is entirely different from any other station.

We venture the assertion that there are very few people in Chicago who have any idea of the tremendous amount of work that had to be done in planning the new terminal. It was necessary to re-locate streets, water mains, sewers and bridges over the Chicago River, to say nothing of all of the railroad facilities that are directly a part of the Station project. While this work was going on the war broke out and operations were suspended for a time, during which a change in business conditions and methods dictated an entire redesign. Members of the Society are already familiar with the work that was done on the foundations as described in a paper by Mr. D'Esposito published in our Journal in February, 1924. There were a number of other investigations that had to be made as for example, the manner of removing locomotive steam and gases from the train sheds. Other problems in lighting, heating, mechanical apparatus, signaling, track layouts, passenger accomodations and countless other subjects were investigated in a similar manner. These studies have all been written up into the form of papers, to be presented before the Western Society The order in which these subjects will be presented by Mr. D'Esposito and his associates has not yet been exactly determined. Those branches which naturally fall into one of the major divisions of engineering will be associated together and presented in one evening.

J. L. Hecht, Past President W. S. E. has been elected Chairman of the Washington Award Commission for the current year. This Commission is composed of nine members of the Western Society of Engineers and two members from each of the four national Societies. The Commission administers the Washington Award which is conferred each year for preeminent services in promoting the public welfare. W. L. Abbott, Past President, W. S. E. has been Chairman of the Commission for the three years past, during which time awards have been conferred upon Robert W. Hunt, Arthur N. Talbot and Jonas Waldo Smith.

Combined Outing and Inspection Trip

The success of the boat trip to Michigan City a year ago has prompted our Excursion Committee to attempt another combined outing and inspection trip for which there is a strong demand from the members. The Committee has endeavored in vain to make arrangements for a satisfactory boat trip during the summer months, but there were too many obstacles in the way. It is believed that a motor trip will be equally enjoyable, as the members who wish, can take their families.

Plans are now being prepared for a trip through the Illinois River Valley, Saturday, October 17th. Briefly, the plan is for the party to leave Chicago at about 10:30 or 11:00 A. M., Saturday, under the guidance of a pilot car furnished by the Chamber of Commerce at La Salle. A stop will be made at Joliet for luncheon and inspection of some of the engineering works in connection with the Illinois Waterway, or at one of the industries there as may be selected. Other stops will be made during the afternoon, to inspect some of the other industries located between Joliet and La Salle. At the latter point there are several interesting factories, such as cement mills, zinc factories, clock factories, wire mills, etc. The Chamber of Commerce at La Salle is anxious to co-operate with the Society and arrange a good trip and assures us that ample hotel accommodations can be arranged.

The evening may be spent in informal dancing or small group talks about the work that had been seen during the afternoon, as may be worked out by the Committee.

Sunday can be spent sight seeing through Starved Rock Park, Deer Park and other points of interest in the vicinity, which should be a delightful outing. The party will be free to return to Chicago on Sunday, as best suits the individual convenience of the members.

It is easy to see that it is no simple task to arrange a trip such as this, so the Excursion Committee is asking for an expression of opinion from the Membership of the Society, to give them an indication as to whether the members want such an Excursion and will do their part to make it worth while for the Committee to go ahead and do the work that will be required. All that is asked is that each member tear out the blank from below and return it to the Secretary, or drop him a line and say whether he would like to have such an excursion arranged. If there are not enough replies received to justify the work, the matter will be dropped, but it is hoped that there will be a good response to this request. Any suggestion as to points of particular interest, that the members would like to visit, will also be welcomed.

The probable expense will be between $5.00 and $8.00 a person. The outing feature alone ought to be worth that much, to say nothing of the opportunity of visiting some industrial and engineering works of interest.

Please help the committee by expressing your opinion promptly.

(This does not commit you to a definite reservation)

Would you join in the Excursion to La Salle, October 17?..................

Can you furnish a Car?..................

How many can you take in addition to your own party?..................

If you do not have a Car, do you want to go with some one who has?..................

Name..................

Inspect Sewage Treatment Plant

The world's largest activated sludge plant for the treatment of sewage was inspected by our members on Saturday, August 15, at the time of our Mid-summer Excursion. It has not been customary to hold many excursions during the summer months, except as occasion seem to indicate to be desirable. In this instance the work at the plant had progressed to such a stage that in another two or three weeks many of the interesting features would have been completed.

The North Side Sewage Treatment Works, located north of Howard Street and west of the North Shore Channel in the Village of Niles Center, are designed to serve the villages of Wilmette, Kenilworth, Winnetka and Glencoe, the City of Evanston and that portion of Chicago lying north of Fullerton Avenue.

The initial installation is designed for an average flow of 175 m. g. d. and a population of 800,000 which it is expected will be tributary by 1930.

To bring the sewage to the plant, 14 miles of intercepting sewers ranging in size from 2¼ to 15 feet, will be required. The estimated cost of the interceptors is approximately $11,000,000.

The sewage is to be treated by the activated sludge process. The treatment plant consists of a main sewage pumping station and blower house, grit chambers and coarse screens, preliminary settling tanks, aeration tanks, settling tanks, operating galleries, main building, service building and miscellaneous conduits. A sludge main 18 miles in length for taking the waste sludge to a point west of the city for disposal, is also provided.

The main pumping station and blower house is 307 feet by 187 feet in plan and 68 feet high above the foundations.

Three sewage pumps of the horizontal centrifugal type with a capacity of 100 c.f.s. and two with a capacity of 150 c.f.s. against a total head of 44 feet, are provided, with space for one future unit. The pumps are driven by direct-connected synchronous motors. Three blower units having a capacity of 30,000 cubic feet free air per minute and four of 40,000 cubic feet capacity at a pressure of 7.75 lb. per square inch are provided for compressing the air for aerating the sewage. The blowers are of the centrifugal type and are driven by direct-connected synchronous motors. The pump and blower house also contains the transformers and other electrical equipment required for the plant Equipment for cleaning and conditioning the air is also provided.

The grit chambers, 12 in number are 8 feet wide with a 4.5 foot effective water depth and 80 feet long. They provide for a velocity of 1 foot per second. They are followed by coarse screens having one-inch clear openings. Equipment for removing the grit and screenings is provided. The grit chambers and coarse screens are housed in a one-story brick building, 147 feet square.

The preliminary settling tanks, 8 in number, are each 80 feet square and have a 14-foot water depth. They are designed to remove the coarser solids and will provide a detention period of 30 minutes. Equipment for automatically removing the sludge is provided.

The aeration units are divided into three batteries each containing 12 aeration tanks 420 feet long, 34.75 feet wide and with a 15-foot water depth and 10 settling tanks 77 feet square and 15.75 feet deep with an operating gallery between, containing the meters and control valves. Each aeration tank is divided into two compartments by a central longitudinal baffle. Air is supplied to the sewage through porous plates set in concrete containers on the tank bottoms and supplied with compressed air through a system of piping. The settling tanks are provided with Door clarifiers for removing the sludge. The operating galleries are housed in one-story brick buildings 420 feet long and 21 feet wide. The clarified effluent from the settling tanks will flow to the North Shore Channel through an 11-foot conduit.

The main building consists of a central tower four stories high 58 feet by 48 feet with two wings each 117 feet long by 48 feet wide and two stories high.

The main tower will contain the offices and laboratories. One wing will contain the sludge return pumps which return the sludge from the settling tanks to the incoming raw sewage and the waste sludge pumps which will pump the excess

sludge to the disposal site west of the city. Four sludge return pumps each with a capacity of 30 m.g.d. against a head of 9.5 feet and two waste sludge pumps each with a capactiy of 1.4 m.d.g. against a head of 180 feet, are provided. All pumps will be horizontal centrifugal units, motor driven. The waste sludge will be discharged through a 14-inch cast-iron force main 18 miles long. The other wing of the main building contains the main sewage meters, store rooms and quarters for the men employed about the plant.

A service building is provided containing the heating plant, repair shops and storage space.

Complete metering and control equipment is provided so that all parts of the process may be properly controlled. All buildings will be of mingled matte pressed brick with granite and Bedford Stone trim.

A railroad siding from Chicago & Northwestern R. R. is provided for delivering coal and other supplies to the plant and it is intended to landscape the grounds about the plant and to make it as attractive as possible.

The entire cost of the treatment plant proper will be about $13,500,000.

Perhaps the thing that attracted the most attention was the construction plant erected by the Contractors, John Griffiths & Sons Co. A cable way with a span of 800 feet and carrying a bucket holding seven yards of concrete served the entire area of the plant. About 75 members and guests were on hand to go over the plant. They were met by representatives of the Contracts and of the Sanitary District of Chicago, Engineering Department who were very courteous in explaining everything that was seen.

F. W. Seidensticker, M. W. S. E. has responded to the note in the August 1925 issue of the Journal in reference to a certain number of the earlier issues of *Machinery* which were missing from our Library. We still lack Volume 1 of that magazine. Perhaps some of our members may have it and would be willing to turn it over to the Library, so that our set will be complete.

Engineering Societies Employment Service Started

On September 1, 1925, the Chicago Office of the Engineering Societies Employment Service was opened in Room 1736 Monadnock Block. This room is next to and connected with the offices of the Western Society of Engineers.

The Chicago Office will be managed by a local committee of representatives of the five societies represented as follows:

Edgar S. Nethercut, Chairman and Treasurer, representing W. S. E.

H. J. Burt, representing Am. Soc. C. E.

D. Levinger, representing A. I. M. E.

H. S. Dickerson, representing A. S. M. E.

A. B. Gates, representing A. I. E. E.

The Engineering Societies Employment Service has been in operation in New York for seven years and is under the direction of the Secretaries of A. S. C. E., A. I. M. E., A. S. M. E. and A. I. E. E. Walter V. Brown is the manager. This service succeeded a similar service conducted by the American Engineering Council for some years, which had succeeded A. S. M. E. and A. I. E. E.

When taken over by the four founder societies there was introduced a voluntary fee, believing that the members of the societies using the service would willingly support the service and help defray the expenses. On this basis the New York service has become self supporting.

Believing that members of the societies residing near Chicago, or desiring positions in the Middle West could be served more readily by an office in Chicago, this office has been opened and the Western Society has joined the founder societies.

In order to finance the new office the New York Office, Engineering Societies Employment Service and the Western Society of Engineers, have joined in advancing the necessary funds.

The Western Society of Engineers has discontinued the free employment service previously carried on and which has been very satisfactory to our members.

The voluntary fee is in the form of a

contribution, based upon the amount of salary.

Members securing a position through the Engineering Societies Employment Service are invited to share with the societies in the financing of the Employment Service by a nominal contribution. It is believed that a successful service can be developed if these contributions average:

$10.00 for all positions paying a salary of $2,000 or less per annum.

$10.00 plus one per cent of all salary in excess of above.

Temporary positions (one month or less) three per cent of total salary received. One month or over, either three per cent of total salary received or at the yearly rate for permanent positions. Contributions payable upon receipt of first month's salary.

The service is open to members in good standing of the five societies.

The new office will be known as the Engineering Societies Employment Service, Chicago Branch and will be under the management of A. Krauser, who has made a special study of employment psychology, vocational guidance, etc. Mr. Krauser was employed for about five years in different divisions of the American Telephone & Telegraph Co., having to do particularly with employment problems. He was in charge in the Engineering Employment Division of the Western Electric Co. for some time. Mr. Krauser brings to the Employment Service, special knowledge of the particular requirements of that kind of work. It is his idea that the best results are obtained where the man is specially chosen to fit the particular opening.

Actual operation of the service will be about as follows. Openings will be solicited from employers whether they are members of the Society or not.

An important part of this work is to show employers where they can use engineering talent in positions which have not heretofore been considered of a technical nature. Members of the Western Society who are employers are requested to list any openings in their organization with the Employment Service.

Members of any of the five societies who wish to secure positions may register with the Employment Service. They may file a complete record of their professional experience on forms which are provided in the office. The Employment Service will make an effort to put them in touch with employers who will be able to make the best use of their talent and experience.

There will be a weekly bulletin of "positions available" to which prospective applicants may subscribe for a nominal fee. This bulletin will contain notices of positions open. Another bulletin may later be issued to employers containing brief summaries of the professional experience of men who are registered with the Employment Service, so that in case employers are interested in a man having particular qualifications, they will be able to get in touch with him through the Service.

All positions open and all applicants for positions will be identified by a number.

Mr. Walter V. Brown, Manager, New York Office, has been in consultation with the Chicago Committees for several days. This has resulted in considerable advantage in planning the work here. Mr. Brown's experience covers over eight years as manager of the service under the auspices of the American Engineering Council and the four founder societies. We are indebted to him for his valuable advice.

This service for members of the societies can be made very useful. We believe it can serve the employers of technical men in this vicinity.

Employers may be sure that applicants for positions are members of one or more of these societies, who, before admission have established their good character and also technical experience and qualifications for the grade of membership they hold in these societies.

Members who desire employees who are themselves members may well consider this as a manner of emphasizing the confidence they have in the organized profession.

Remember the address, Engineering Societies Employment Service, Chicago Office, Room 1736 53 W. Jackson Blvd. Telephone, Harrison 1238.

Representative Named on Research Council

The Division of Engineering and Industrial Research of the National Research Council is made up of representatives of Engineering Societies and large manufacturing interests all over the country. The Research Council is for the purpose of co-ordinating and directing research work along all lines, both engineering, sociological, scientific and others. The representative of the Western Society of Engineers for the past three years has been E. O. Schweitzer, Chief Testing Engineer, Commonwealth Edison Co., Chicago. His term expired June 1, 1925.

Inasmuch as many of the meetings of this Division are held in New York it was thought advisable to appoint one of our New York members if possible. Peter Junkersfeld, M. W. S. E., Vice-President, and General Manager, McClellan and Junkersfeld, Consulting Engineers of New York has been selected. Mr. Junkersfeld was in Chicago for a number of years, where he became well known to many of our members.

Young Men's Forum Becomes Junior Society

A report from the Executive Committee of the Young Men's Forum submitted to the Board of Direction at its August meeting and approved by the Board, marks the passing of the Young Men's Forum to a new and larger organization known as the "Junior Engineers of the Western Society." The report submitted by the Executive Committee of the Forum which had a most successful year just past is as follows:

"As requested the Executive Comittee submit the following report and recommendations:

"It is recommended to the Board of Direction of the Western Society of Engineers:

"That the *Junior Engineers of the Western Society of Engineers* be established to provide opportunities for increasing knowledge, fellowship, and progress among the younger members of the Society.

"That the activities of the *Junior Engineers of Western Society of Engineers* be so directed as to interest those in the Student and Junior grades of membership in actively participating in its affairs so as to prepare themselves for places of responsibility in the Society.

"That the *Junior Engineers* meet during the hour just preceding the presentation of technical programs before the Society (usually Monday) and at such other times as may be decided by its Executive Committee.

"That the activities of the *Junior Engineers* be directed by an Executive Committee appointed by the Board of Directions of the Society, from names submitted by the group. This Committee to consist of a Chairman, Vice-Chairman, Secretary and four other members.

"That Mr. L. M. Traiser (Chairman), Mr. R. B. Bohman (Vice-Chairman), Mr. F. A. Hess (Secretary), Mr. C. J. Michelet, Mr. D. T. Waby, Mr. W. K. Flavin and Mr. Lee Bird, be suggested for the first executive committee.

"Respectifully submitted by the Committee:

C. J. Michelet, Chairman
E. A. Armstrong
F. A. Hess
L. M. Traiser
R. B. Bohman
Willis Rabbe, Secretary."

In approving this report the Board of Direction approved the appointment of the Executive Committee as suggested. That is the Committee which will have charge of the affairs of the Junior Engineers during the coming year.

It is believed that the change of meeting time to the hour just preceding the technical meetings on Monday nights will result in much larger attendance at these meetings. It has been evident for some time that two evenings a week was too many to expect the younger members to devote to Society affairs, and many of them want to take advantage of the technical meetings on Monday.

The young men have been associated continuously since the days immediately after the War, when the organization was first formed as a sort of a round table for committee discussion, etc.

Members Serve on Safety Commission

The Cook County Safety Commission appointed by President Anton J. Cermak of the County Board, consisting of fourteen public officials and prominent citizens, includes five members of the Western Society of Engineers who are in a position to contribute noteworthy public service because of their engineering training. Those included on the Committee are: Maj. George A. Quinlan, Superintendent of Highways, who is Chairman of the Commission; B. J. Fallon, Vice-President Chicago Elevated lines; J. S. Pole, Engineer Track Elevation, Chicago & Northwestern R. R.; R. A. Cook, Chief Engineer, Chicago & Alton R. R.; Robert Ford, Assistant to Chief Engineer, Rock Island Lines, all of whom are members of the Society. This commission is appointed to make a study of automobile traffic accidents and make recommendations for preventing them. Studies will be made of grade separations, signals at crossings, watchmen and other protective measures at dangerous points. This movement should have the full support of all public spirited citizens.

The fall meeting of the American Welding Society is to be held at the Massachusetts Institute of Technology, Cambridge, Mass., Oct. 21, 22 and 23. A complete program of technical papers, demonstration of welding and cutting operations and some entertainment features has been arranged, in five technical sessions. The Chicago Section of this Society holds its monthly meetings in our rooms.

Enlarged Budget Adopted

The Board of Direction adopted the budget for this year at its August meeting including a number of items of expense not required in years past. This involves not only the expense incident to the remodeling of the Society's rooms, but also some additions in equipment that have been badly needed. A condensed summary of the budget is given below:

INCOME

		Budget	Actual Last Year
Entrance Fees		$ 2,400.00	$ 2,339.50
Members Acct. Rec.		26,333.00	26,314.13
Dues New Members		1,800.00	1,700.00
Year Book Sub.		2,070.00	1,992.00
Advertising—			
Journal	$2,800.00		2,642.63
Year Book	675.00	3,475.00	670.00
Interest—			
Investments		700.00	792.26
Deposits		50.00	66.81
Misc. Accts. Rec.		2,375.00	2,285.68
Total		$39,203.00	$38,803.01

EXPENSE

Acct.	Budget	Actual Last Year
A—General Expense	$18,432.00	$18,926.68
B—Technical Meetings	2,810.00	2,605.12
C—Publications	10,585.00	9,881.42
D—Library	3,735.00	3,969.24
E—Entertainment-Excursion Committee	955.00	1,003.53
F—Other Committee Expense	1,065.00	1,180.84
Total	$37,582.00	$37,566.83
Assets. Libr.	1,010.00	1,470.81
Expense	$36,572.00	$36,096.02

BUDGET—(Continued)

Additional Expense

Due to Changes in Rooms			
½ Alteration Expense	$ 1,650.00		
Moving Expense, Library	210.00		
Moving Expense, Office	100.00		
Fixtures, Lighting	325.00		
Total	$2,285.00		
One-third to this year's operating expense			$761.66
Equipment			
Library: Stacks	594.00		
Files	74.26	$668.26	
Office: Transfer Cases	22.80		
Addressograph	320.00		
Folding Machine	270.00		
Ediphone	175.00		
Shaving Machine	75.00	1,862.80	
Auditorium: New Chairs		30.00	
Total Equipment			1,561.96
Employment Service Advance			1,000.00
Total Additional Expense			$3,322.72
Total Operating Expense			37,582,00
Total Expense Budget			$40,904.72

Committees Appointed

Appointments to committees of the Society as approved by the Board of Direction are given in the following list. The men who are serving on these committees are giving freely of their time for the advancement of the Society's interests. One of the privileges of membership in the Society is the opportunity to serve on committees. Those who take advantage of this opportunity profit in a personal way by extending their acquaintance among engineers. They enjoy this association and feel amply repaid for the time spent in the service of the committees on which they are enrolled.

Finance Committee

George W. Hand, Chairman, C. & N. W. Ry., 226 W. Jackson Blvd. Dear. 2121.

D. J. Brumley, Illinois Central R. R. Central Sta. Wab. 2200.

E. O. Griffenhagen, 155 E. Superior St. Sup. 7297.

Membership Committee

A. J. Schafmayer, Chairman, Board of Local Imp., City Hall. Main 0447.

G. R. Brandon, A. L. Stevens, 28 E. Jackson Blvd. Harr. 8060.

E. J. Fowler, Commonwealth Edison Co., 72 W. Adams St. Rand. 1280, Loc. 421.

D. W. Chapman, Peoples Gas Light & Coke Co., 122 S. Michigan. Wab. 6000.

D. B. Rush, Rm. 2200 Insurance Exchange Bldg. Wab. 0872.

Amendments Committee

Chas. A. Morse, Chairman, Rm. 803 La Salle St. Station. Wab. 3200.

J. L. Hecht, 72 W. Adams St. Rand. 2510.

E. T. Howson, 608 S. Dearborn St. Harr. 0027.

W. G. Nusz, Illinois Central R. R. 1201 S. Michigan Ave. Wab. 2200.

E. A. Rummler, 7 S. Dearborn St. Cent. 3418.

Program Committee

W. A. Shaw, Chairman, 30 N. La Salle St. Main 5166.

E. D. Swift, Rm. 315 Dearborn St. Station. Harr. 3690.

C. L. Post, 53 W. Jackson Blvd. Condron & Post. Harr. 0069.

W. S. Lacher, 608 S. Dearborn St. Harr. 0027.

F. G. Vent, Illinois Central R. R. Central Sta. Wab. 2200, Loc. 380.

R. I. Parker, General Electric Co. 320 S. Clark St. Dear. 9800.

C. A. Schnerr, Peoples Gas Light & Coke Co., 3921 S. Wabash Ave. Boul. 2831.

John A. Dailey, Rm. 408 City Hall. Main 0447, Ext. 193.

E. J. Teberg, Public Service Co., 72 W. Adams St. Rand. 2510.

C. P. Richardson, 803 La Salle Station. Wab. 3200.

F. R. Quayle, 1001 W. Van Buren St., Automatic Electric Co. Monroe 3200.

J. D. Cunningham, 2240 Diversey Pkwy. Brunswick 6000.

Publication Committee

O. F. Dalstrom, Chairman, C. & N. W. Ry., 226 W. Jackson Blvd. Dear. 2121.

Paul Hansen, 6 N. Michigan Ave. State 7256.

A. Herz, Public Service Co., 72 W. Adams St. Rand. 2510.

M. H. Riley, Ill. Bell Tel. Co., 212 W. Washington St. Off. 9300, Ext. 728.

C. H. Mottier, Ill. Central R. R., 1201 S. Wabash Ave. Wab. 2200, Loc. 29.

John C. Penn, Armour Institute, 33rd & Federal Sts. Vict. 4600.

John W. Woermann, 537 S. Dearborn St. Harr. 0668.

Ralph Turner, Technical Publishing Co., 537 S. Dearborn St. Harr. 0824.

Rowland Manley, Peoples Gas Co., 122 S. Michigan Ave. Wab. 6000, Loc. 240.

Wm. Wurth, Rm. 1620 Peoples Gas Bldg. Wab. 6000, Loc. 139.

E. P. Rich, 431 S. Dearborn St. Harr. 7691.

Library Committee

C. C. Whittier, Chairman, Rm. 2200 Insurance Exch. Bldg. Wab. 0872.

H. H. Field, Rm. 736 Bldg. Rand. 1280, Loc. 879.

C. G. Atkins, 53 W. Jackson Blvd. Harr. 2135.

L. F. Harza, 53 W. Jackson Blvd. Harr. 0774.

M. M. Fowler, General Electric Co., 230 S. Clark St. Dear. 9800.

Entertainment Committee

J. W. Lowell, Jr., Chairman, Benedict Stone, Inc., 74th & Ashland. Triangle 1378.

Murray Blanchard, 1404 Kimball Bldg. Harr. 7284.

John Hodgson, Illinois Appraisal Co., 230 S. Clark St. Cen. 0567.

L. E. Mitchell, Morgan Gardner Elec. Co. Vict. 2431.

T. Frank Quilty, 5 N. La Salle St. Frank. 5644.

G. A. Saint, 226 W. Jackson Blvd., C. & N. W. Ry. Dear. 2121.

Excursion Committee

W. H. Robertson, Chairman, Massey Conc. Prod. Corp., 122 S. Michigan Ave. Harr. 4410.

Maro Johnson, Illinois Central R. R., 135 E. 11th Pl. Wab. 2200, Local 491.

B. S. Pfeiffer, 38 S. Dearborn St. Cent. 5468.

S. A. Rhodes, Ill. Bell Tel. Co., 212 W. Washington St. Off. 9300.

A. R. Mitchell, Rm. 1243 Railway Exchange Bldg. Harr. 4900.

Noonday Lunch Committee

S. A. Greeley, Chairman, 6. N. Michigan Ave., Rm. 1710. State 7256.

P. D. Van Vliet, Rm. 914 Monadnock Block. Harr. 4841.

P. A. Poppenhusen, Rm. 622 McCormick Bldg. Harr. 2483.

E. A. Armstrong, Public Service Co., 72 W. Adams St. Rand. 2510, Loc. 150.

W. J. Lynch, Thompson-Starrett Co., 104 S. Michigan Ave. Dear. 8320.

Development Committee

A. L. Rice, Chairman, Technical Pub. Co., 537 S. Dearborn St. Harr. 0824.

Paul Westburg, 53 W. Jackson Blvd. Harr. 0745.

John Brunner, Illinois Steel Co., 208 S. La Salle St. Wab. 0980.

L. W. Skov, C. B. & Q. R. R., 547 W. Jackson Blvd. Cent. 5311.

R. H. Ford, 803 La Salle St. Station. Wab. 3200.

C. C. Brooks, Mead-Morrison Mfg. Co., 53 W. Jackson Blvd. Harr. 4546.

W. G. Arn, Illinois Central R. R. Central Sta. Wab. 2200, Local 37.

Increase of Membership Committee

E. J. Dowdall, Chairman, Univ. Port. Cem. Co., 208 S. La Salle. Wab. 6160.

W. M. Randolph, Western Elec. Co., Hawthorne Sta., Chicago. Lawn 5000, Local 1739.

Frank Brown, Holabird & Roche, 1400 Monroe Bldg. Rand. 5960.

L. E. Seas, Mellon-Stuart Co., 808 Fisher Bldg. Harr. 4458.

Edwin A. Howes, Rm. 523 Burnham Bldg., Bd. of Local Improv. Main 0447, Ext. 396.

Building Code Committee

J. L. McConnell, Chairman, 111 W. Jackson Blvd. Harr. 8979.

Julius Floto, Rm. 1023 Monadnock Block. Harr. 2959.

Robert Knight, Rm. 702 City Hall. Main 0447.

H. A. Durr, 123 W. Madison St. Rand. 3705.

J. D'Esposito, Chicago Union Station, 517 W. Adams St. State 4116.

Hugh E. Young, 525 Burnham Bldg. Main 0447, Loc. 375.

H. J. Burt, Rm. 1400 Monroe Bldg. Rand. 5960.

Andrews Allen, 21 E. Van Buren St. Harr. 2472.

Public Affairs Committee

C. E. DeLeuw, Chairman, Rm. 1204 Conway Bldg. State 4692.

A. P. Allen, Vice Chairman, Ill. Bell Tel. Co., 212 W. Washington St. Off. 9300.

Secretary, E. L. Jones, Rm. 1121-133 W. Washington St. Main 4790.

Asst. Sec'y. J. M. Mercer, Rm. 1735 Monadnock Block. Harr. 7162.

Members. R. I. Randolph, Rm. 1210-38 S. Dearborn St. Rand. 6044; H. L. Kellogg, 5648 W. 65th St. Pros. 7007; R. W. Putnam, 537 S. Dearborn St. Harr. 0668.

Committee on Simplified Practice

W. A. Durgin, Chairman, Commonwealth Edison Co., 72 W. Adams St. Rand. 1280.

Geo. Niestadt, 53 W. Jackson Blvd. Harr. 3550.

F. K. Copeland, Sullivan Machinery Co., 122 S. Michigan Ave. Harr. 3390.

R. C. Wieboldt, 1534 W. Van Buren St. Haymarket 8400.

G. A. Hagganđer, 547 W. Jackson Blvd. Cent. 5311.

John Brunner, Rm. 1633-208 S. La Salle St. Wab. 0980.

On the Value of Library Service

From time to time we have published short articles in the Journal, pointing out certain features of the Library. We have wondered whether the members ever took these articles seriously or whether they really believed that there was any merit in our library. The following letter received by the Secretary indicates that the service given by the Library is worth more than passing attention. Horace Carpenter, M. W. S. E. writes as follows under date of August 8th:

"I think a word of commendation is due the Society regarding its library service.

"Some eight or nine months ago, I had occasion to consult the library, looking for some publication covering the theory of a problem in which I was interested.

"I knew so little about the matter myself that I was unable to give your Librarian any intelligent idea of what I wanted, and at that time, my search was unsuccessful and a similar search in other quarters indicated that there was no published matter covering the question. However, I was in the library a day or two ago on another matter and your Librarian asked me if I was still interested in the previous problem and handed me a publication covering the matter.

"It certainly seems to me that this shows a sustained interest on the part of any librarian who will carry in mind for a period of months the casual inquiry of a member."

This is not a single outstanding incident for we have had many other compliments on the measure of service given by the Library, most of which reflect special credit on the Librarian. The Society has been fortunate in the past few years in having Librarians who were conscientious about their work and put forth real efforts to find information sought by members. Our present Librarian, Miss Krieg has been especially conscientious in this regard.

It is the Society's misfortune that Miss Krieg is soon to leave us to take up a more responsible position as head of the Catalog Department of the Library of the University of Iowa at Iowa City. In

accepting this appointment, Miss Krieg is able to realize an ambition of long standing, to have complete charge of the Catalog of a large and diversified Library. The officers and members of the Society wish her continued success in her new location. Our Library Committee is now making an effort to secure a successor to Miss Krieg, who will be equally competent and able to maintain the Library on the high plane of service to the members that has been the rule heretofore.

Addresses Wanted

Will the members of the Society kindly look over the following list and advise the Secretary of the present address of any of the men shown thereon whom they may happen to know. In each case mail has been returned from the address given and we are unable to communicate with them. Telephone calls to all the references in our files have failed to locate these men. Any help given by the members will be gratefully appreciated.

Donald W. Akey, 419 S. Superior St., Angola, Ind.
B. B. Arcenas, 601 Columbia St., Seattle, Wash.
Delancey P. Bliss, 510 S. Euclid St., Angola, Ind.
Roy M. Boger, 414 S. Wayne St., Angola, Ind.
Curtis Brown, Box 137, Angola, Ind.
J. R. Culver, 3819 Janssen Ave., Chicago, Ill.
Samuel Deutsch, 701 N. Michigan Ave., Chicago, Ill.
F. C. French, Durant Motor Co., Elizabeth, N. J.
Spencer Gill, Box 23, Angola, Ind.
Thomas Goby, 411 N. Wayne St., Angola, Ind.
C. A. E. Gower, 1645 N. Washington Ave., Mason City, Ia.
Jesse H. Grant, 5714 Blackstone Ave., Chicago, Ill.
Edw. A. Green, Bentmere Hotel, 601 Diversey Parkway, Chicago, Ill.
Celso Guanco, Box 189, Angola, Ind.
Pedro Guevara, Box 177, Angola, Ind.
M. W. Herriman, 902 Petroleum Bldg., Tulsa, Okla.
Donald Hilliker, 300 S. West St., Angola, Ind.
John Humphries, 413 S. College St., Angola, Ind.
C. A. Kaiser, Engineer of Bridges, I. C. R. R., Chicago, Ill.
H. F. Koch, 223 S. Kinney St., Angola, Ind.
A. Krattinger, General Delivery, Newark, N. J.
Marion W. Lang, 211 S. Darling St., Angola, Ind.
Henry McGuire, 21 Leslie Ave., Highland Park, Ill.
Arthur S. Magill, 209 S. West St., Angola, Ind.
Hugo A. Peterson, 428 N. Superior St., Angola, Ind.
W. H. Schott, 9 E. 46th St., New York City.
S. Trood, 5540 Phillips Ave., Pittsburgh, Pa.
Robt. K. Tullis, 107 Sixth St., Toronto, Ohio.
John K. Wiley, 416 S. Superior St., Angola, Ind.
Eugene A. Wright, 430 Ohio Ave., Etowah, Tenn.

J. W. Lowell, Jr., M. W. S. E. after fourteen years service with the Universal Portland Cement Co., has resigned his position as Manager of the Service Bureau, to become Vice-President of Benedict Stone, Inc., at 74th and Ashland Ave., Chicago.

This company operates three plants, one of which is in Canada, for the manufacture of artificial stone, which is widely used throughout the East in fine hotels and other buildings where ornamental stone work is employed. Their plant in Chicago is the largest cut stone plant in the city.

Mr. Lowell has been interested in the Western Society of Engineers for a good many years and has served on numerous committees. He has also taken an active part in the American Concrete Institute, where he has served on important committes dealing with concrete products and specifications for them. His recent connection is an example of the tendency among manufacturers to seek engineers, for executive positions in which non-technical men have heretofore been employed. The company with which he is now connected furnished the ornamental stone work for the Grant Park Stadium and a number of other buildings in Chicago.

Nation's Seventh Largest Hydro Plant to Be Developed at Louisville

THE enormous volume of water carried by the famous Ohio River is to be put to work in the development of electricity on a large scale, according to an announcement by Standard Gas and Electric Company. With the issuance of a license by the Federal Power Commission to the Louisville Hydro-Electric Company—one of Standard's units—work is to be started at once on the first modern power development of the Ohio.

This plant, to be located at Louisville, Ky., will be one of the largest single hydro-electric plants in the United States, being exceeded in installed capacity by but six others. The initial capacity will be 108,000 horsepower in eight 13,500 horsepower units, with provision for an ultimate capacity of 135,000 horsepower.

Both from engineering and economic viewpoints the Ohio Falls development, carried out in co-operation with the government and its waterway program, is of unusual interest and will be watched keenly by students of these questions through the entire country.

The development of power at the falls of the Ohio is made possible by the construction of a dam nearly two miles long by the Federal government, as part of its plan to establish a nine-foot stage of water for navigation of the river from Pittsburgh to Cairo. The dam, at an approximate height of twenty feet, will extend obliquely across the river from the Indiana shore to Rock Island, which lies near what was formerly the historic old town of Shippingsport, one of the earliest settlements at what is now Louisville.

Between Rock Island and the Kentucky shore a powerhouse, 507 feet long, will be constructed under the supervision of the Byllesby Engineering and Management Corporation, at an estimated cost of $7,500,000. The cost of the dam to be built by the government will be $3,250,000, the entire project thus entailing an expenditure of $10,750,000. The hydro company will pay the government an annual rental for use of the power. It is expected that a yearly average output of 357,000,000 kilowatt-hours can be produced by the water wheels operating under a maximum head of 37 feet.

Power from the Ohio Falls development, which is to be completed not later than early in 1929, will be distributed primarily in Louisville by the Louisville Gas and Electric Company, of which the hydro company is a subsidiary. Transmission lines will connect Ohio Falls with the Louisville company's 123,500 horsepower Waterside steam plant, in order that hydro and steam power plant operation may be carried on most effectively. By 1929, however, it is expected that the electrical demands of Louisville and surrounding territory will have increased to a point where a large new steam plant will be necessary. Plans have been made for the erection of the steam plant with an ultimate capacity of 250,000 horsepower adjacent to the hydro power house at Shippingsport.

Both the hydro and steam power plant developments will increase Louisville's already important position in the super power system of the Middle West and South, which has now reached a considerable stage of development. Louisville Gas and Electric Company is at present connected with large transmission networks in Kentucky and Indiana, and the natural and transportation advantages of the city make it a dominant electrical production site for a great area extending in all directions.

It is encouraging to note that the collection of current dues from members in the Society continues to exceed collections at similar dates in the last two or three years. Perhaps this indicates a condition of more general prosperity. It is certain that the energies heretofore devoted to collecting the dues of those members who defer their payments can be reduced just in proportion to the number who prefer to wait until the end of the year, rather than to make payment at the beginning of the year. Unfortunately, there are some who neglect this matter until the very last thing. It causes the Society considerable extra labor and expense.

Standardizing Surety Bonds

Conferences of representatives of contractors, surety associations and public officials have been held during the past year in an attempt to work out methods and practices that will be of great importance to the construction industry in the matter of surety bonds and methods of conducting business handled by contract. The first conference was called in Washington, June 7, 1924, at the Department of Commerce. Secretary Herbert Hoover, outlined briefly the necessity for establishing self-regulation of industry within each group, rather than attempting to enforce governmental regulation. He said that the economical structure of the country has become so complex that the individual is no longer able to meet the multitude of business forces, and that cooperation by organizations offers the only hope of keeping the United States an individualistic nation with proper development of private initiative. Prior to the calling of this conference a statement of the points to be considered was sent to all interested so that when the thirty conferees assembled they were prepared to take up the work of the meeting intelligently. The preliminary discussion of the eight subjects enumerated in this outline resulted in the formation of three special sub-committees with subjects assigned to them for report.

Committee No. 1 was ordered to report on the following subjects:

(A) Risk or credit bureau for ascertaining responsibility of contractors.

(B) Free service of surety companies-estimating, engineering advice, bidding information, etc.

Committee No. 2 was to report on:

(A) Qualifications of contractors and financial statements.

(B) Progress reports of construction.

(C) Uniform contracts for construction.

(D) Day labor construction.

Committee No. 3 was assigned:

(A) Forms of surety other than the corporate surety bond.

(B) Uniform enforcement of time penalty in construction contracts.

(C) Publication of name of surety on each construction contract.

The second meeting was held at White Sulphur Springs, September 20, 1924, at which the reports of these committees were received.

The reports of the sub-committees are somewhat lengthy and give evidence of having been based upon careful study. Committee No. 1 reported that it is strongly of the opinion that territorial bureaus with a central control office as a clearing house, offer the practical method of instituting reforms in present practices whereby irresponsible contractors and irresponsible surety companies may be restrained from participation in contract work. The practice of giving free services such as estimating, engineering, bidding information, etc., by surety companies is not to be permitted. The committee further recommends that committees of the Associated General Contractors of America, the American Association of State Highway Officials and the Surety Association of America meet together from time to time to discuss their common interests and problems.

Committee No. 2 recommended that a uniform financial statement for determining the qualifications of contractors be submitted to the conference for adoption and then referred to the Surety Association of America with the recommendation that it be made a standard form for surety companies. The committee could not see any particular advantage in the adoption of a uniform progress report but expressed no adverse opinion if the conference desired to adopt such. As to uniform contracts for construction the committee is firmly of the belief that a uniform contract should be adopted, and recommended that a form for construction contracts based as nearly as possible upon that prepared by the joint conference on standard construction contracts be adopted. As to day labor construction of public works, the committee expressed itself very strongly as being opposed to such practice which it characterized as an encroachment of government upon private industry.

Committee No. 3 reporting on the question of forms of surety other than the corporate surety bond stated that negotiable securities and greater retained percentages may be more satisfactorily used

in the order named than personal surety which is considered least desirable. It is believed that if the measures considered by the conference could be put into effect the corporate bond can be made satisfactory. Uniform enforcement of time penalties of a contract was recommended. It also recommended that the name of the surety for each construction contract be published on all public construction work and that public officials notify the home office of the surety company when the bond is received.

After a thorough discussion of all the points set forth in these different reports, each of them was accepted in turn. There was a lively discussion on the subject of furnishing free engineering and other services to contractors by surety companies which was condemned. It was recommended that surety companies continue to maintain engineers for work within their own organizations and for their own protection.

The Western Society of Engineers was one of the organizations participating in the formation of the standard construction contract. The Society has been asked to participate in the conference on surety bonds. Our Board of Direction has authorized the President to appoint a representative.

Schedule of Meetings, 1925-6

Following is the schedule adopted for the technical meetings for this year:

Sept. 14—Bridge and Structural Section.
Sept. 21—Gas Section.
Sept. 28—Electrical Section.
Oct. 5—Railroad Section.
Oct. 12—Mechanical Section.
Oct. 19—Telephone, Telegraph & Radio Section.
Oct. 26—Hydraulic, Sanitary & Municipal Section.
Nov. 2—Illuminating Section.
Nov. 9—Bridge and Structural Section.
Nov. 16—Gas Section.
Nov. 23—Electrical Section.
Nov. 30—Mechanical Section.
Dec. 7—Telephone, Telegraph & Radio Section.
Dec. 14—Hydraulic, Sanitary & Municipal Section.
Dec. 21—Bridge and Structural Section.
Jan. 4—Gas Section.
Jan. 11—Electrical Section.
Jan. 18—Railroad Section.
Jan. 25—Mechanical Section. (Power Show.)
Feb. 1—Hydraulic, Sanitary & Municipal Section.
Feb. 8—Illuminating Section.
Feb. 15—Bridge & Structural Section.
Mar. 1—Electrical Section.
Mar. 8—Railroad Section. (A. R. E. A.)
Mar. 15—Gas Section. (Ill. Gas.)
Mar. 22—Mechanical Section.
Mar. 29—Telephone, Telegraph & Radio Section.
Apr. 5—Bridge & Structural Section.
Apr. 12—Hydraulic, Sanitary & Municipal Section.
Apr. 19—Electrical Section.
Apr. 26—Railroad Section.
May 3—Mechanical Section.
May 10—Telephone, Telegraph & Radio Section.
May 17—Gas Section.
May 24—Illuminating Section.

Onward Bates, Honorary member, Western Society of Engineers has ordered a copy "Memoirs and Addresses of Two Decades" by Dr. J. A. L. Waddell, M. W. S. E. which he has presented to the Library of the Society. The Society is grateful to Mr. Bates for this gift.

D. J. Price, who has twice presented papers before the Western Society of Engineers on the subject of Dust Explosions has resigned his position as engineer in charge of development work in the Bureau of Chemistry, U. S. Department of Agriculture to take up a position with the Mine Safety Appliances Company, Pittsburgh, Pa. Many of our members will recall his appearances before the Society.

C. W. Breed, M. W. S. E. formerly Office Engineer, C. B. & Q. R. R. Co. has been appointed Engineer of Standards of that Company, according to the announcement by A. W. Newton, M. W. S. E., Chief Engineer, C. B. & Q. R. R. under date of August 22nd.

APPLICATIONS FOR MEMBERSHIP

Members of the Society can be of great service if they will make a practice of examining the list of applicants published herewith and promptly notifying the Membership Committee or the Secretary regarding the qualifications of any of those whose names appear on the list. The Society desires to extend its membership and rceive those engineers who have the proper qualifications and wish to participate in its activities. The following applications have been received since last report:

No.	Name	Address
191—1925	Lvernon Bunch	Angola, Indiana.
192	Theodore Kimball	308 S. Superior St., Angola, Ind.
193	Martin Nelson	Y. M. C. A. Hotel, Chicago, Ill.
194	Wilbur G. Thompson	Cazenovia, N. Y.
195	Floyd C. Double	Cortland, Ohio.
196	C. F. Boake	53 W. Jackson Blvd., Chicago.
197	M. H. Genena, (Trans.)	White City, Kansas.
198	D. Oliver, (Transfer)	Pedro de Macoris, Rep. Dominicana.
199	H. T. Moorman	1725 Wilson Ave., Chicago, Ill.

NEW MEMBERS

The following were elected to membership in the grade indicated by the Board of Direction, at its meeting held August 17, 1925:

No.	Name	Address	Grade
153—1925	Lewis C. Halpin, (Transfer)	Box 252, Glens Falls, N. Y.	Associate
155	Girard Nardone, (Trans.)	3 Pleasant St., Westerly, R. I.	Junior
158	Edwin G. Slone	400 S. College St., Angola, Ind.	Student
159	E. L. Fetcher, (Trans.)	124 Hill St. Bucyrus, O.	Junior
162	Walter O. Moros	405 W. Gilmore St., Angola, Ind.	Student
166	Harold J. Holmquest, (Transfer)	220 S. Lotus Ave., Chicago	Associate
167	George R. Herrmann	1122 N. La Salle St.	Junior
168	Richard E. Ostland	3108 Oak Park Ave., Berwyn	Junior
170	John N. Ostrum	547 W. Jackson Blvd., Chicago	Member
171	Fritz W. Wandschneider,	311 N. Central Ave., Chicago	Junior
172	Chas. S. Frink, Jr.	349 Weadock Ave., Saginaw, Mich.	Junior
173	George W. Swallow	814 Marquette Bldg., Chicago	Associate
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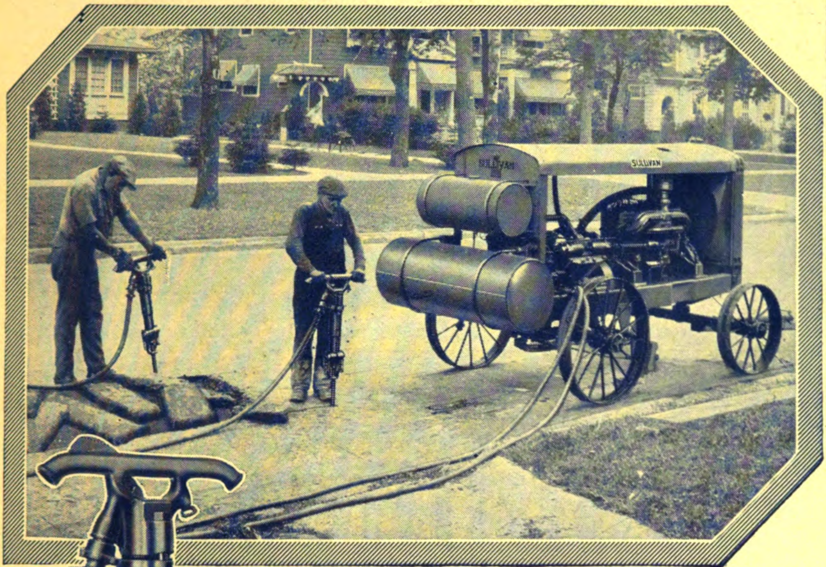
178	James W. Cohn	3718 Douglas Blvd., Chicago	Member
180	Howard E. Norton	614 Central Ave., Wilmette	Junior
181	Edward F. Webb, (Trans.)	358 E. 70th Pl., Chicago	Junior
183	Edward F. Weber, (Transfer)	355 Anthony St. Glen Ellyn	Associate
186	Alfred E. Rand, (Trans.)	Hummer Plow Wks., Springfield	Junior
187	Richard B. Berry, (Trans.)	508 S. Lawndale Ave., Chicago	Member
188	John E. McCauley	7344 Drexel Ave., Chicago	Junior
190	A. R. Lepin, (Trans.)	43 Latrobe Ave., Chicago	Associate



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This beautiful Cleveland residence street was restored to service quicker and with less inconvenience to the public, because the contractors, Joseph Kalill and Jackson Co., used a Sullivan Portable Compressor and Sullivan "Busters" to cut the asphalt and concrete pavement.

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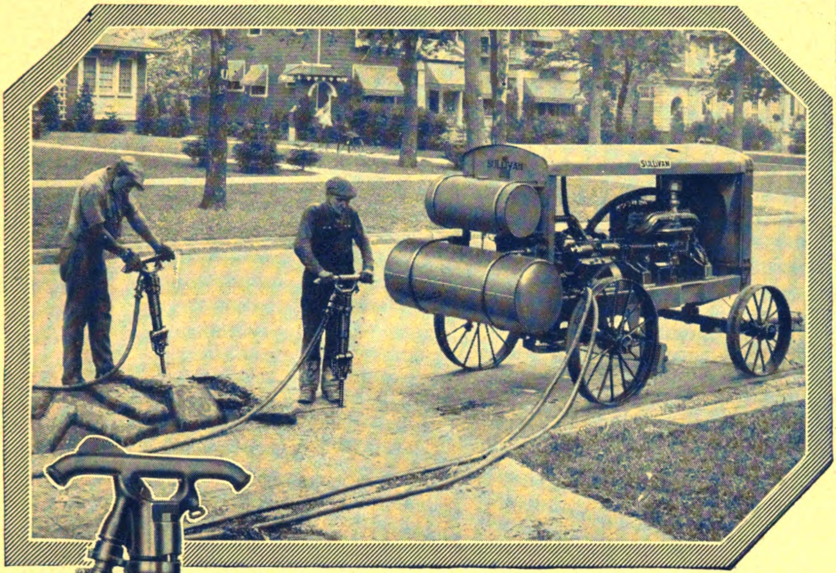

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MEETINGS IN NOVEMBER

November promises to be a very busy month for the Western Society of Engineers with five technical meetings, a housewarming, a Noonday luncheon, an excursion and a number of Committee meetings. So far this year the attendance at meetings in our rooms has been holding up to standard. Those who attend, comment favorably upon the new arrangements and particularly upon the fact that the new ventilating system is effective, which removes one of the worst objections that was heard in reference to the old rooms. It is noticeable that the new arrangement which eliminates the street noises, makes it much easier to hear the average speaker in the back of the room.

Dinner Meeting With I. E. S.

November 2 will be a meeting that will be something of an innovation for us, as we are going to join in a dinner meeting with the Illuminating Engineering Society, Chicago Section, at the Electric Club, 30 N. Dearborn St. The general subject of this meeting is to be, "Relighting Chicago Factories." Dinner will be served at 6 o'clock and the meeting will begin at about 7. Those who do not wish to come for dinner are welcome to come later if they wish to do so. There will be some motion pictures just released by the National Electric Lamp Division, entitled, "Yesterday and Today." Following this, L. V. James one of the Engineers of the Midland Lamp Division of G. E. Co., will give an illustrated address on factory illumination, comparing former methods of factory lighting with those used today. Mr. James will use a demonstrating equipment which has been built at considerable expense to demonstrate the actual effects secured in lighting by means of different kinds of apparatus. There will be a novelty sketch presented by two players called "Nob" and "Toobe" entitled, "Bought and Aint Paid For." This will be a travesty on methods of electric wiring.

Use of Hooks in Concrete

Monday, November 9 will be a meeting of special interest to structural engineers. T. D. Mylrea, Asst. Prof. of Structural Engineering at the University of Illinois will give a paper on the use of hook bars in reinforcing concrete. Prof. Mylrea has been doing a great deal of research work on concrete reinforcement for a number of years. He has developed the theoretical and practical side of this question. His paper will discuss the cases when it is necessary to use anchors on the ends of reinforcing bars, and describe the types of anchors in use. Following this is an analysis of stresses in steel and concrete at the bend or hook. He also discusses the distribution of the pull on a hook and the resulting splitting effects and how to overcome them. Prof. Mylrea has reached some definite conclusions as to when it is desirable to use hooks and when not to use them.

In arranging for this paper, the Committee has asked Prof. Mylrea to bear in mind particularly the use of reinforced concrete as specified in the Chicago Building Code. It is the plan to have this subject, covered in such a manner that the information brought out at this meeting will be useful in studies of the

Chicago Building Code, which many engineers believe is in need of a thorough revision, particularly as to the requirements for concrete and steel. Later meetings will be devoted to other sections of the Building Code with a view to determining certain recommendations which the Society could sponsor.

Utilization of Waste Heat in Steel Mills

F. H. Wilcox, Vice-President, Freyn Engineering Co., Chicago, will be the speaker on Monday, November 16, at which time he will present a paper on the "Utilization of Waste Heat in Steel Mills." This paper is based on a number of years of study and experiment by Mr. Wilcox and his associates, which has resulted in the development of a new type of waste heat boilers. His paper goes into the theory of heat transfer in both water tube and marine type boilers and presents data on that subject which we understand have not been published heretofore. Mr. Wilcox proposes to illustrate his paper with a discussion of a typical steel mill, giving the description of the sources of waste heat and the cost of the installation to recover this heat that is wasted. He will also analyze the power requirements that may be met by a waste heat installation and the savings that may be expected from it.

The operation of a steel mill is so complex and there are so many varying conditions that the practice does not always follow out the theory. For this reason, this paper will be listened to with a great deal of interest, not only on the part of those of our members who are concerned in the operation of boilers, but also, on the part of those who are interested in steel mill operation.

This will be a joint meeting with the Chicago Section, American Society of Mechanical Engineers.

Mercury Arc Rectifiers

Monday, November 23 will be a joint meeting with the Chicago Section, American Institute of Electrical Engineers, at which time L. T. Robinson, Electrical Engineer, General Electric Co., Schenectady, N. Y., will present a paper on "Mercury Arc Rectifiers." The last few years have seen remarkable developments in the use of rectifiers of all sizes for converting alternating current into direct. They are being substituted for rotary converters in substations now. There is one installation on order in Chicago at the present time, for heavy service where rectifiers will be used instead of rotary converters.

Small size rectifiers have become extremely popular due to their large use for battery charging. This paper will include a theoretical discussion of the engineering principles involved and the efficiencies obtained. It is reported that American practice is far behind European in this respect, as the use of large size rectifiers for electric traction is quite extensive over there.

By-Product Recovery

The last technical meeting in November will occur November 30, when Chester S. Heath, M. W. S. E., Superintendent of the refining plant of the Peoples Gas Light & Coke Co., Chicago, will present a paper on, "Recovery of By-Products in the Gas Industry."

Motor fuel, coal tar, ammonium sulphate and other products are recovered in the manufacture of gas, to say nothing of coke which is a by-product of the coal gas ovens. Some of these by-products are of suicient value to pay the cost of recovery, while others are not so profitable. This paper will tell how the by-products are recovered and the methods of treating them. It will not be possible to go into all of the derivatives of coal tar which includes more than a thousand different chemicals, dyes and other products.

It is encouraging to note that the different sections have practically completed their programs for the rest of the Society's year, or until next June. Some excellent papers have been scheduled and we look forward to a number of most interesting meetings.

Arthur Edwards, one of the Junior members of the Society, who was formerly associated with Sargent & Lundy in Chicago, is now in the employ of Stone & Webster, being located for the time being in the Boston office. He writes that he finds the work with this company very interesting.

Unusual Bridges in Grant Park

The first meeting on the technical program for this year was held September 14 in the Society's remodeled rooms. C. R. Hoyt, Structural Engineer, South Park Commissioners, presented a paper giving a description of the bridges being erected over the Illinois Central R. R. tracks in Grant Park, north of 12th Street.

There are a number of limiting conditions which made the design of these bridges rather unusual. The City ordinances prohibit any structure extending above the top of the retaining walls in Grant Park, so this automatically eliminated any sort of truss spans which would have been highly desirable because of the necessity for utilizing every possible inch of the right of way for tracks. This also limited the depth of the girders because it was necessary to preserve the required clearance for the passage of trains. Thus the clearance studies were made with a great deal of care to develop the most economical arrangement.

The right of-way to be spanned by these bridges is 200 feet wide and it became necessary to design bridges with unequal span lengths in order to find space to locate the columns, and the columns were reduced to the smallest possible dimensions, so as to take up as little space between tracks as possible.

Studies of all the different types of structures possible under these limiting conditions were made and it was decided that the continuous girder type met all the requirements best and permitted a kind of construction that would be acceptable from the standpoint of appearance. Mr. Hoyt gave illustrations of the different steps in these studies, pointing out the methods that were used and the conclusions that were reached with the reasons for them. The fact that the railroad company may be compelled to build additional tracks on a lower level at some future time was a determining factor in the designing of the foundations which are cylinder piers sunk to bed rock and extending to about the lower track level. Slender steel columns extend from this point upward to the girders to which they are rigidly connected. The interest in this subject was shown by the discussion which followed the reading of the paper. Mr. Hoyt's paper is published in this issue of the Journal.

Underground Corrosion Classified

The second meeting of the Society's new year was held September 21, at which time a paper on "Corrosion of Underground Utility Structures," by A. J. Fecht was read. The author of this paper was unable to be present, so it was read by J. M. Mercer, Assistant to the Secretary, and the meeting thrown open for general discussion.

Mr. Fecht was associated with William G. Woolfolk, Consulting Engineer of Chicago for some time and prior to that had done considerable work with the Bureau of Standards on electrolysis investigations in different parts of the country and at Washington. This paper first gave a description of the methods used for measuring electrolytic current, explaining the steps which led up to the development of the earth current meter, the instrument now used in making nearly all these investigations. Some examples were given of a typical investigation showing how the currents in the earth are measured and plotted with reference to the location of the structure being studied and other contributing factors, such as street car rails, utility power cables, water mains, etc. In one of the examples given there was a photograph of a service pipe which passed under the street car tracks. That part lying directly under the street car rails was almost entirely eaten away, while the part further away remained in good condition.

There were other examples given where the corrosion caused by acid condition of the soil, as indicated by the effect on short samples of unconnected pipes was more distructive than that caused by any stray currents, and there were other examples given where the direction of the flow of current was such as to actually protect the pipe against corrosive action.

Mr. Fecht presented some very inter-

esting data on the effect of different kinds of soil on pipes as determined by the Bureau of Standards in an extensive survey, including some forty cities in the United States.

The discussion following the presentation of this paper was constructive and showed the large amount of interest in the subject on the part of the engineers in this vicinity, particularly those connected with public utilities of one kind or another. It brought out the fact that not all corrosion of underground structures can be attributed to electrolysis, as there are many other factors, such as chemical and galvanic action caused by local conditions in the structure. This was a problem which is causing a great deal of trouble in the oil fields where the casings of oil wells are being destroyed by an agency which has not yet been determined, but which appears to be a combination of chemical and local galvanic action. According to a representative of the State Geologist's office, who was present at this meeting, this is a problem which is extremely important in the oil fields in southern Illinois. Here the production of oil is so small that any extra expense caused by destruction of the well casing bears a large proportion to the total output of the well.

INTEREST IN UNION STATION MEETINGS

One of the biggest things that the Western Society of Engineers has attempted in recent years in the way of technical meetings, was the series of three meetings recently devoted to the Chicago Union Station. When the Program Committee first began to plan for these meetings, it soon became apparent that there was so much material to be covered, that it would be impossible to present it even in abstract in one meeting. The subjects naturally divided themselves into general divisions, such as, structural and construction features, electrical and mechanical features and the tracks, signals and general plan. Accordingly, this was the division which was maintained in arranging the meetings.

Monday, September 28 was the first meeting, at which E. Weidemann, M. W. S. E. and E. E. Stetson, M. W. S. E. were the speakers.

All three of these meetings were held in the assembly room on the mezzanine floor of the Station. This room seated 250 persons comfortably and was filled to capacity at each of the meetings. The fact of having the meeting in the Station instead of our own rooms, added considerably to the interest shown, as it afforded an opportunity for our members to go to the station and actually see the things that were being described There were many who took advantage of the excellent restaurants in the Station, to have dinner there.

Mr. Weidemann presented an excellent paper in which he gave a description of the complicated structure that is required in this Station. This is one of the largest buildings in the country and although it is now only eight stories in height, it is built to provide for the ultimate addition of fourteen more stories as soon as is necessary to provide an office building above the main structure. The main waiting room which extends North and South to the entire length of the headhouse is kept free of columns by the use of enormous girders at each end which will carry the weight of the structure to be built above. Mr. Weidemann's paper also included a description of the structure of the mail terminal building which is the largest building in the world, devoted exclusively to the handling of mail. More than three thousand tons of second, third and fourth class mail is handled through this building every business day.

Some of the most unusual structures are

employed in the concourse and train sheds. The noticeable thing about both of them is the unusual number of curved members instead of the straight pieces commonly employed.

Construction Program

E. E. Stetson, M. W. S. E. Assistant Engineer of the Union Station Co., described the construction program. When one realizes that the construction of the Union Station involved everything from the building of sewers to the installation of lights, all of which had to be done while the normal traffic through the station was being maintained without interruption, it is easy to realize that the construction program had to be worked out very carefully. It was not the case of doing just one thing at a time and completing it before starting another operation, it was more the matter of doing as much of one operation as could be done at a time, without interfering with another operation that was going on at the same time and also without interrupting traffic Here was where the most careful kind of planning was necessary and the greatest credit is due to the engineers of the Union Station Co., for having completed this piece of work under the conditions which existed.

Mechanical Equipment

The evening of October 5 was given over to the electrical and mechanical work, which was of considerable magnitude and quite complicated. Edison Brock, M. W. S. E., Mechanical Engineer, Chicago Union Station Co., described that part of the station equipment which would be classed as mechanical. This included the heating, ventilating, plumbing, refrigeration and a number of other divisions. A separate heating plant was built to furnish heat for the station buildings and the mail terminal. Part of the heating is done by direct radiation, part by the indirect system, and part by forced circulation of hot water, depending upon the particular conditions met in the area served. This in itself involved a great deal of designing. The ventilating equipment for the station and concourse building has capacity for moving two million cubic feet of air per minute, which gives some idea of the size of the installation. The air is filtered instead of being washed as has been done in many large installations heretofore. This is accomplished by passing it through crates filled with steel wool saturated with oil. These crates or sections are removed about once a month and washed to remove the dust and dirt collected out of the air. There are thirty-two refrigerating plants in the Station and a kitchen with capacity for serving ten thousand meals a day. More than half that number are now being served in the normal flow of traffic through the Station.

One of the factors which had an important bearing on the design of the station was the method of handling baggage. It was decided to handle all baggage to and from train by means of tractors and trailers, operating on separate platforms, connected with the baggage room by ramps. A special trailer was designed which would permit operation in trains which could be operated from either end. This system is so efficient that when a passenger alights from a train, his baggage will be delivered to the baggage counter before he can walk to the counter to claim it. The use of separate platforms and ramps instead of tunnels and elevators. is a new principle in station design, and in this case has proved to be decidedly satisfactory. Mr. Brock very correctly compared Chicago Union Station to an iceberg, eighty-five per cent of which is below the surface. Little does the public realize from the fifteen per cent that it sees above the surface, how much work is involved in building and operating a station such as this.

Electrical Apparatus

Clifford W. Post, Electrical Engineer of the Chicago Union Station Co., read a paper describing the electrical apparatus installed therein. The electrical power used by the Station is purchased in bulk from the Commonwealth Edison Co. and delivered to the sub-station on the premises, where it is transformed and converted as required for whatever use is to be made of it. This sub-station is located in the sub-basement which is well below the level of the Chicago River and had to be carefully guarded against possible flooding. The machines are all mounted on pedestals, so that in case of a possible accident to the sewers, or pumping

system, the station can be kept in operation, even though there may be as much as 18 inches of water on the floor.

A fundamental requirement in this station, is the continuity of service, and every safeguard is employed to make sure that there will be no interruption. In general the lighting systems are laid out in duplicate, so that in case of accident to one circuit, at least half the lights could be maintained in operation. In case both systems are put out of commission, there is an automatic emergency lighting outfit which furnishes sufficient light at all exits and stairways, to avoid any danger of panic. There are a number of unusual power requirements, such as train lighting system, signal systems, etc., in addition to the usual telephone and lighting equipment, all of which required special treatment. Some new developments were worked out in connection with the telephone switchboard and the offices where reservations are made by telephone for parlor car and sleeping car accomodations. The distribution through the building includes some unusual features, such as a large number of extra outlets for possible future connections for power and telephone service.

Tracks and Track Layout

Monday, October 12, was given over to the general plan and design features of the Station which included the tracks and track layouts and the signal systems. Clarence J. Noland, M. W. S. E., Assistant Engineer who had charge of the track work, described the tracks and switching arrangements. The whole area of Station property was first very carefully surveyed and an accurate map made up on the coordinate system, by means of which any point in the yard could be very accurately determined. In the construction of the yard this was very important, because it was possible to build only one or two tracks at a time, in order not to interrupt the regular traffic. The tracks are laid on concrete slabs ten inches thick. Instead of using ballast the ties are embedded in a secondary concrete slab sloping towards the center to provide drainage. Short blocks under each rail are used, instead of the regular railroad ties. The drainage and track details which had to be worked out were quite interesting and complicated. The ordinary severe summer thunder shower will develop a runoff of about forty thousand gallons a minute, which has to be taken care of by pumps if necessary. The great flexibility of train movements, desired in designing the Station, made the track layouts, a matter of greatest importance.

Signals and Interlocking

Closely allied to the subject of track layouts, is the matter of signals and interlocking equipment. This was discussed by Thomas Holt, M. W. S. E. Signal Engineer of the station company. It was thought undesirable to make use of the well known semaphore type of signals in an improvement as beautiful as the New Union Station, so a new type of position light signal was designed. These signals are used on the viaducts, spanning the station property and thus eliminate the construction of signal bridges. The signals are inconspicuous but yet very efficient. There are fourteen station tracks in the south yard and ten in the north yard. Each yard is operated from its own signal tower independently of the other. There are six approach tracks from the south and four from the north and a train can be switched from any approach track to any station track. Proper interlocking to safeguard these train movements and signaling to govern them, makes this installation one of the largest in the world. The switches are operated by compressed air, controlled by electric controlling apparatus. Each tower has an illuminated track diagram which indicates whether any section of the track in the station is occupied and the position of the signals governing that section.

As would be expected in a station of this kind, every known precaution is made use of to insure the correct operation of trains without accident.

The real climax of this series of meetings came at the end of the third session, when J. D'Esposito, M. W. S. E., Chief Engineer, Chicago Union Station Co., summed up the general features and told about how the actual plans for the sta-

tion were arrived at. Mr. D'Esposito had intended to make this statement at the opening of the first meeting, but was confined to his home by illness at the time. He paid a remarkable tribute to his associates in the engineering department of the Company, for the work that they have done in designing the Station. He said that the credit for its successful completion belonged to them rather than to him.

Development of General Plan

Mr. D'Esposito told in his own interesting way, how the first plans were conceived and then how it became necessary to modify them from time to time as conditions brought on by the war seemed to make necessary. In describing this evolution of the station plans, he illustrated a number of the more typical designs by lantern slides, explaining the important advantages and disadvantages of each. There were over seventy plans considered before the final decision was made and it is the feeling of all concerned, that the enormous amount of work that has gone into the designing of this structure has been justified by the results that were obtained. Chicago can now justly claim one of the world's finest railroad terminals. This is in reality a public utility in which will be found almost every kind of engineering that is known, represented in some way or another. It is truly an engineering accomplishment.

The Board of Direction of the Western Society of Engineers, recognizing the immense amount of work that the speakers put into the preparation of these papers for the Society and recognizing the courtesy of the Station Company in allowing the Society to use the room designated for holding these meetings, instructed the Secretary to send the following letter to Mr. D'Esposito.

Dear Mr. D'Esposito:

"It is with peculiar pleasure that I write you this letter. At a meeting of the Board of Direction held October 19th, there was a great deal of interest shown in the series of three meetings on the Chicago Union Station. The Board of Direction instructed me to write you and advise you of their great appreciation of the arrangements for the series of three meetings, the splendid character of the papers presented and the use of the Assembly Room at the Union Station for these meetings. The Board desires to include in this letter of appreciation, the members of your staff who contributed the papers, Messrs. Weidemann, Stetson, Brock, Post, Noland and Holt, and the other members of your staff who assisted in the conduct of the meeting.

"The Chicago Union Station is a utility of vast proportions and in the design, construction and operation of this Station, your staff of engineers, each having his special division assigned to him, because of his ability and interest in that particular line, made it possible for you as Chief, to coordinate and consummate this Station. To have the engineering story of this utility presented in a series of three meetings and presented in the form of papers, discussing intimately the problems of each element of the Station project, was quite remarkable. This series of meetings served to illustrate the interrelation of engineers of many specialties in one large project. The Society is indebted to you and your staff, for this splendid cooperation."

"With personal regards.

Yours truly,

Edgar S. Nethercut,

Secretary."

These papers are being prepared for publication in a special issue of the Journal which will be in fact a complete story of the building of the Chicago Union Station. Mr. D'Esposito found in his studies of terminals built heretofore, that there is practically nothing in the literature of engineering pertaining to the fundamental plans of station design. Aside from the contribution of that material, the description of the details of construction will form a valuable addition to engineering literature. The labor of preparing all this material for publication is considerable and may result in some delay in the publication of the November Journal.

See Asbestos Made

One of the most interesting excursions that the Society has held in a long time, was that on September 18th, when about 75 of our members and guests went to the new plant of Johns-Manville Inc., at Asbestos, Ill., just north of Waukegan. As this plant is immediately north of the new station of the Public Service Co., of Northern Illinois, there were several who took advantage of the opportunity to inspect it also.

Special arrangements had been made with the Chicago & Northwestern Railroad Company to accommodate the party on one of the through trains, which left Chicago at 11:30 A. M. A special car was provided and this train stopped at the station of Asbestos, located at the entrance to the plant. One of the suburban trains was run out from Waukegan to pick up the party at 4:25 and made all the regular suburban stops on the trip back to Chicago, so the transportation was all that could be asked.

On arrival at the plant, the party was shown through a section of one of the shops, during the interval while the cafeteria was being made ready to serve a special luncheon after serving the regular meal to the employees. At one o'clock the party was served an excellent luncheon by the young ladies employed in the factory offices, who volunteered their services. After luncheon the party started on the inspection through the factory.

The factory occupies seven buildings averaging 200 ft. wide and 1,000 ft. long. It is located on the shore of Lake Michigan, so the abundant supply of water required for manufacturing operations, may be obtained easily. The products manufactured are all of interest to engineers in one way or another. Perhaps one of the best known products is the magnesia pipe covering used for insulating steam pipes and boilers. The shop where this covering is made was the first one visited. Dolomite limestone from which the magnesia is obtained is burned in large kilns about the size of a blast furnace, after which the lime is hydrated and the magnesium is precipitated out by chemical process and dried. This is then mixed with a required amount of asbestos fibre, pressed into moulds and dried, after which it is handled about like so much lumber.

The departments where asbestos paper is made were quite interesting. The fibre is treated in beaters and washers, like in an ordinary paper mill. Several different kinds of asbestos paper are made here in mills which proved to be very interesting. After the paper is dried, it is passed through a number of special machines which make it up into different combinations and shapes for different uses. It is corrugated and wound on forms which make it into pipe covering of all sizes, up to 24 inches in diameter, after which it is packed in assorted sizes for shipment. It is interesting to note that the experience of the Company has shown that nearly every order will contain an assortment of sizes. Most orders can therefore be filled from these standard packages which are made up in advance, and held ready for shipment.

Other departments aroused a similar degree of interest on the part of the visitors. Artificial shingles of several different kinds are made in this plant. Some of them are rigid like slate, while others are the familiar asbestos felt impregnated with asphalt and covered with gravel. Many of the visitors were surprised at the number of uses that are made of the product known as transite board, which is used as a building material, insulating material for electrical construction, locomotive smoke jacks and a variety of other uses, some of which required special treatment. This material is made in enormous presses, which squeeze the water out, preparatory to baking in ovens.

The departments manufacturing sheet and rod packing, brake band linings, etc., were entirely different. Here the asbestos fibre is spun into yarn and woven like cloth or given other special treatments, as may be required.

This plant also manufactures a number of products using asbestos, such as furnace cement, flooring, brake linings, clutch facing, waterproofing materials. electrical conduits and many moulded products, too numerous to be described in detail.

Most of the asbestos fibre comes from

the Company's mines in Quebec, and Arizona. It is given preliminary treatment at the mines, as the ore contains only about five per cent of asbestos fibre in its natural state. The crude fibre is shipped to the factories. The American product has a short fibre averaging about a quarter of an inch in length. For the finer products, an imported African fibre averaging six to eight inches long, is used.

Lectures on Radio and "Ido"

Prof. Morgan Brooks, M. W. S. E., Professor of Electrical Engineering was the speaker at our meeting October 19th. He took for his subject, "Aspects and Prospects of Radio the Outgrowth of a Century of Telegraphy." In asking Prof. Brooks to speak, the committee in charge suggested to him that he give a general outline of the developments in all the different methods of communications with some of his views as to developments that might be expected in the future.

One of the most striking things to Prof. Brooks was the fact that radio, the newest wonder of science is particularly the work of younger men and it is not uncommon to find boys who know more about the subject than most of their elders. Perhaps this is possible because investigation and research in radio may be conducted without the extensive outlay of capital often required in other lines of study. Another factor is the growing realization of the importance of research.

Perhaps not many people know that the typewriter which is so important to us today, is the direct result of the printing telegraph which was in use before commercial typewriters were thought of. Although the telegraph has been in use for more than a century, it is only in the past year than any spectacular progress has been made in its improvement. This refers to the new high speed submarine cable recently placed in service under the Atlantic Ocean.

The idea of broadcasting is generally associated with radio, and accredited to it, but it is known that broadcasting by telephone was practiced in Europe as early as 1910. Although the telephone is primarily for private and secret communication, yet this use was made of it in broadcasting operas, musical programs, sermons, etc.

Turning to the future of radio, Prof. Brooks pointed out some of the things that are greatly to be desired and which may come as the result of continued research. Among those he mentioned were the following. It would be a fine thing if there were some way of accurately controlling the direction of radio signals and some means for the receiving station to identify, the station from which the signals are being received. The big problem of reducing interference by static, will be a difficult one to solve. We are now sending pictures by wire, but there seems to be no prospect of sending more than the ordinary photograph by radio.

The speaker raised the question so often heard from various sources as to what will be the future of radio broadcasting. It is conceivable that a saturation point will be reached sometime, when it will be necessary to find some additional sources of revenue to support the expensive broadcasting stations that are now in operation. Perhaps new uses will be discovered, which will simplify the problem.

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internaciona relati, ula naturala linguo, exemple Angla o Franca, nam to donus tro grand avantajo a la populo di qua ol esas la matrala linguo. Ni devos havar neutra linguo, quale Ido, qua esas reguloza, preciza, klara, fonetikala ed eufona. Omni qui deziras obtenar informi pri Ido povas skribar direte a Eugene F. McPike, 5418 Woodlawn Avenue, Chicago.

Translation

On the evening of the 19th of October, 1925, before the Western Society of Engineers, Chicago, Eugene F. McPike discoursed in Ido and English, concerning the problem of an international language for world-communication. He showed thirty-three stereopticon slides in Ido and explained some details of the language. On account of the rapid development of radio, we probably will have a common language before many years. Such a language ought to be constructed scientifically. One would not be able to adopt any natural language, for example, English or French, for that would give too great an advantage to the people of whom it was (is) the mother-tongue. We ought to have a neutral language, such as Ido, which is regular, precise, clear, phonetic and euphonious. All who desire to obtain information about Ido may write direct to Eugene F. McPike, 5418 Woodlawn Avenue, Chicago.

Armour Student Branch Starts Meetings

The Student Branch of the Western Society of Engineers located at Armour Institute of Technology, starts off the season with bright prospects. Officers for this year are: President, G. O. Melby; Vice-President, N. J. Wagner; Secretary, T. S. Schaefer; Treasurer, E. J. Jaros. The Student Branch will hold meetings twice a month, as heretofore. These meetings will be held during one of the recitation periods, allotted to it by the Faculty. This official recognition encourages the Student Members to engage in Engineering Society work.

At the present time an intensive effort is being made to interest the Junior engineers who have just become eligible for membership to associate themselves with the Society. The experience of past years has shown that those students who take a leading part in the affairs of the Student Branch, are nearly always the ones to get ahead faster after they leave school.

"Land Reclamation An Economic Problem"

Dr. Elwood Mead, U. S. Commissioner of Reclamation, Washington, D. C., told the members of the Society at their meeting on October 26, about the many economic problems which overshadow the engineering work in connection with the reclamation of desert lands in the United States. Dr. Mead first described the development of the twenty-four reclamation projects financed by the U. S. Government for the purpose of bringing arid lands under cultivation. The purpose of these developments was commendable and they were well planned, but the human element entering into the growth did not work out as was anticipated. Prior to the last two or three years, the history of these projects have been nearly the same, that is, the projects were conceived on an apparently sound basis, the government spent millions of dollars in building canals and irrigation works and threw the land open to settlement. No attempt was made to select the occupants of the land and much of it fell into the hands of speculators and those who had no intention of occupying or developing the property. Many inexperienced owners became discouraged because of the large amount of the work that had to be put on the land, before it could be made productive, and abandoned their farms. As a result, the government was not repaid for the money that it had spent to bring water into the district to be irrigated. In many cases the cost of the irrigation works exceeds $100.00 per acre and the cost of preparing the land for irrigation varies, sometimes amounting to as much as $150.00 or more per acre.

The problem of the reclamation department is therefore to secure farmers with some little capital to enable them to do the work necessary in development. Dr. Mead's idea is that the government should advance a certain amount of cap-

ital to responsible farmers, to permit them to continue the development of their property when they have demonstrated their own capability and sincerity of purpose.

His paper which gives a concise analysis of the situation is printed in this issue of the Journal.

Mid-West Power Conference

Plans are being perfected for a power conference to be held in Chicago, January 26 to 29.

The committee in charge of the plans consists of:

Arthur L. Rice, Chairman.
G. E. Pfisterer, Secretary.
Karl A. Auty, L. M. Gumm, American Institute of Electrical Engineers.
W. Sykes, W. R. Wright, American Institute of Mining Engineers.
Tom Wilson, Alex. D. Bailey, American Society of Mechanical Engineers.
W. del. Carr, R. F. Schuchardt, National Electric Light Association.
W. D. Keefer, J. I. Benash, National Safety Council.
Walter A. Shaw, E. S. Nethercut, Western Society of Engineers.

It is proposed that the first meeting, on Tuesday afternoon, shall take up the power resources of the country, both for steam and hydraulic power, that Wednesday morning be devoted to a general consideration of the best ways in which those resources may be utilized, and that Wednesday afternoon session take up the trends in economical power generation, dealing largely with the features to be found in big plants.

Economy in small plants is, however, quite as important, and the Thursday morning session will take up the problems of plant layouts and equipment and plant operation in order to secure best economy in moderate sized plants, such as are commonly used in individual industries. The subject will be treated from the standpoint of both steam and hydraulic plants and in connection with this there will be also a talk and demonstration on the rendering of first aid.

Thursday afternoon has been left free for inspection trips to the power plants and developments in and about Chicago and a sub-committee is arranging for these trips.

Thursday evening a dinner will be held, at which prominent speakers will take up the question of the effect of power generation, distribution and use on the social structure and on the economics of industry. This dinner will be held, as will other meetings, in the Furniture Mart Building, where ample facilities are available to handle the large attendance which is expected.

The Friday session will be devoted to the use of oil and gas for power generation. This is in conjunction with the activities of Oil and Gas Power Week, which will be observed throughout the country at that time. The subjects to be taken up will be the Diesel engine, the Diesel electric locomotive, the use of oil as a Boiler Fuel and By-products Gas Plants.

Public Affairs Committee Organized

Our Public Affairs Committee which has been one of the most active in the Society for many years past is now organized for this year's work on a plan which is very similar to the organization of the Society.

About three hundred twenty five members have indicated their desire to serve on the Public Affairs Committee. An Executive Committee consisting of, C. E. DeLeuw, Chairman; A. P. Allen, Vice-Chairman; E. L. Jones, Secretary; J. M. Mercer, Assistant Secretary; R. I. Randolph, H. L. Kellogg and Maj. Rufus W. Putnam has been appointed. The Executive Committee has held several meetings and designated nine sub-committees. Appointments for the chairmanship of these sub-committees are as follows:

Public Finance—E. J. Fowler.
Public Utilities—Paul E. Green.
National Defense—J. deN. Macomb.
Regional Planning—Sidney J. Williams

Waterways—L. R. Howson.
Water Supply and Sewage Disposal—Paul Hansen.
Streets and Street Traffic—A. G. Shaver.
Rail Terminals—H. L. Kellogg.
Public Schools—C. L. Post.

A meeting of the Executive Committee with the Sub-committee chairmen was held in the Society rooms, Monday, October 26, at which time it was determined that the first meeting of the whole committee would be Monday, November 9.

A questionnaire was sent out to all those who registered in the Public Affairs Committee, asking for expressions of opinion as to time and place of meeting, subjects to be discussed and suggestions for appointments on the various committees. Replies from these questionnaires were tabulated and used as a basis for making the appointments and assigning subjects for special study by the sub-committees. The replies to the questionnaire indicated that the best time for meetings is Monday at noon and that it was the desire of the majority to continue serving lunch here, as was done last year. This may be done easily as the rooms are now arranged and will result in no confusion to the meetings. A plain but substantial luncheon is served for fifty cents.

The Executive Committee will function as a sort of program committee and will have charge of special assignments as it may determine through the year. The questionnaires indicated that a scheduled meeting of the whole committee on the second Monday of each month would be sufficient, except as emergencies might require meetings on later Mondays in the month. Accordingly, the Public Affairs Committee will start out on a Program of one regular meeting on the second Monday of each month with the possibility of other meetings as may be required by special circumstances.

Engineering Society Secretaries Meet

A number of the Secretaries of local engineering societies in the vicinity of Cleveland met there for conference on September 12 for a general discussion of the problems and opportunities in local engineering society work. Those present included: C. E. Billin, Secretary, Engineers Club of Philadelphia; E. L. Brandt, Managing Secretary, Detroit Engineering Society; Edgar S. Nethercut, Secretary, Western Society of Engineers; John R. Owen, Secretary, Engineering Society of Buffalo; C. R. Sabin, Secretary-Manager, Cleveland Engineering Society; K. F. Treshow, Secretary, Engineers Society of Western Pennsylvania, Pittsburgh. This conference came at the close of a joint meeting of the Detroit Engineering Society and the Cleveland Engineering Society.

Our Secretary spent Friday, the 11th in Detroit, in conference with the local society there. About a year ago, the Detroit Engineering Society purchased an old residence located about a mile and one-half from the center of the city, which they have remodeled to provide club rooms and meeting rooms and office. They had arranged for a joint inspection trip together with the Cleveland Engineering Society and about sixty of their members went on the boat from Detroit to Cleveland, where the day was spent in inspection trips to points of interest to engineers.

The Secretaries present spent a very profitable day comparing notes and discussing problems of mutual interest. Among the matters discussed were, the relationship of local sections of national societies to the local engineering societies, problems of publication and employment, organization of student sections, standardization service and interchange of membership. Walter V. Brown, Manager of the Engineering Societies Employment Service of New York was on his way home after having spent ten days in Chicago organizing the Chicago office of that service, which is shared by the Western Society of Engineers. He devoted part of the day to conference with the Secretaries, who availed themselves of the opportunity to gather all the information they could from him, concerning the administration of employment service for engineers.

It was the opinion of this group that another conference should be held in April next year and preferably with the

American Engineering Council. Chicago was suggested as the logical place for the next meeting. If this conforms with the plans of the American Engineering Council, such a meeting will undoubtedly be arranged.

There were a number of ideas exchanged at this conference which should prove valuable. There were several which apply directly to conditions as we have them here in Chicago and steps are now being taken to put them into effect.

Distinguish Engineers As Such

Mention was made in the July and August issues of the Journal of the practice of using the word "Engineman" to designate persons whose duties consist of the operation, maintenance and repair of engines of any sort, rather than the word "engineer," which is so commonly employed. It is our feeling that this latter term should be reserved for those whose duties are the design and construction of engineering works, as distinguished from operation or maintenance.

The word was adopted by the U. S. Civil Service in 1920 and was promptly met with strenuous objection on the part of the stationary engineers union who appeared to be willing to accept almost any kind of compromise, rather than give up the word "engineer." The Civil Service Commission sought opinions from a number of large employers of all classes of labor, employment personnel department heads and others who were in a position to speak with some authority. The opinions received were almost unanimous in favoring the distinction as set forth above. A number of societies have interviewed the Director of the Census, with a result that hereafter, the U. S. Census will designate all persons having the care of or operation of stationary or locomotive engineers, as "engineman" in distinction to the word "engineers," as applied to the professional or semi-professional men.

If engineers themselves want to preserve this name as distinctive of their own profession, they can do their part by seeing to it that each one uses the distinctive words properly in his own work. This situation has been created only by custom and it can be corrected only by the same means.

One member of the Society who has been engaged in doing work for a half dozen of the larger American cities has recommended this distinction in employment classification and terminology, with a result that it has been adopted in nearly all of them.

W. L. Abbott Becomes President A. S. M. E.

The Annual Meeting of the American Society of Mechanical Engineers will be held in New York, November 30 to December 4, 1925. The business meetings will be held on Monday and beginning Tuesday morning, the technical divisions will hold simultaneous sessions until Thursday afternoon. The technical meetings will be classified under general headings as follows: Oil and Gas Power, Machine Shop Practice, Wood Industries, Industrial Power, Railroad, Centrifugal Compressors, Calculation Methods, Industrial Furnaces, Materials Handling, Machine Shop Practice, Springs, Steam Power, Management, Aeronautics, Textiles, Power Plant Materials, Industrial Psychology, Lubrication, and Design. There will be other sessions devoted to lectures, public hearings on researches and education and training for industries. Friday will be devoted to business meetings and excursions.

W. L. Abbott, Past President W. S. E., will assume office as President of the American Society of Mechanical Engineers at this time. On Tuesday evening, Honorary memberships will be awarded to Herbert Hoover and W. R. Warner. The Annual Dinner will be on Wednesday evening, while Thursday will be devoted to addresses on National Defense. Mr. Abbott, who was President of the Western Society in 1907, served on the Board of Managers of the American Society of Mechanical Engineers from 1907-1910. He has been a member of that organization since 1891.

Committee Sponsors Appointed

A feature of the plan of organization of the Western Society of Engineers is that of appointing members of the Board of Direction, as sponsors for the standing committees of the Society. The Board has appointed the following to be sponsors of the Committees shown after their respective names:

Mr. Hand—Finance.
Mr. Morrow—Program and Development.
Mr. Fowler—Publication and Library.
Maj. Putnam—Public Affairs and Noonday Lunch.
Mr. Garcia—Entertainment and Excursion.
Mr. Cauley—Increase of Membership and Simplified Practice.
Mr. Chase—Junior Engineers and Building Code.

This gives each committee a direct representative on the Board of Direction through whom a close contact is established.

American Construction Council Meets in Chicago

The Fourth Annual Meting of the American Construction Council will be a four day session and will be held on November 18th to 21st, 1925, at the Congress Hotel, Chicago, Illinois.

One of the principal features of the meeting will be a national conference on Better Building. This conference is designed to bring out the particular place that each branch of the industry holds in the entire problem of Better Building and its relation to the public. The place of craftsmanship and apprentice training in Better Building will also receive consideration.

The American Construction Council has been particularly vigorous on the problem of. Better Building, having inaugurated several years ago a nation-wide campaign to promote better quality of construction and sounder financing in building especially housing.

The third day of the Council's meeting will begin with a general session on the reduction of construction peaks and depressions. Aside from general discussion there will be a report of the joint committee of the Council and the American Railway Association on the coordination of publicity for a country-wide campaign on greater stabilization of construction.

There will also be a session on local building congresses. Another session will be devoted to the place of commercial arbitration in the construction industry with special reference to its national aspects.

On Saturday, November 21st, there will be a national conference on highway construction, particularly as it relates to better building of highways.

Group metings of the constituent elements of the Council for discussion of special problems and the election of representatives to the Council's Board of Governors will be held.

The Red Cross Arrives

There is a time-worn newspaper line which almost invariably accompanies the report of an international disturbance in some lesser hot spot of the earth, which states, "The Marines have landed." It conveys the feeling that the strong arm of the United States is reaching out to insure safety.

Rivalling this famous line in familiarity is that one which very frequently brings the only message of cheer from a region riven by calamity; it states, "The Red Cross has arrived."

It means that the skilfully-directed resources of a nation-wide organization dedicated to the service of humanity in need have been thrown into action with the same celerity and effectiveness with which the country's armed forces respond to the call to battle.

Chartered by Congress for this work, the American Red Cross is always ready: ready with clothing, medical assistance, food, shelter, and the thousand and one things needed in the first dazed period of disaster whether by fire or flood. Behind its services in such times is more than forty years of experience in such work, directing the efforts of trained workers; backed by an enrolled reserve of 41,000 nurses, with funds kept ready, the Red Cross can go on the job wherever the call comes from.

In 700 major calamities occurring in the United States in the past 44 years, the American Red Cross has expended $48,000,000 of its own and specially contributed funds, in meeting the contingencies arising, besides rendering its usual prompt aid of all kinds.

Like the armed forces, the Red Cross goes overseas when necessary, and because of the efficiency of its organized efforts, functions with the same effectiveness as it does at home.

The Annual Roll Call, from November 11, to November 26, when it seeks membership, is the opportunity the Red Cross extends to all Americans to share in the glory of its service.

On account of the inability of J. W. Lowell, Jr. to serve as chairman of the Entertainment Committee, Murray Blanchard, M. W. S. E. has been selected and is now acting in that capacity. The Entertainment Committee plans a series of at least four entertainments, before the end of the fiscal year, two of which will be for ladies and the remainder will be devoted more particularly to the men.

Fred M. Lyon, Aff. W. S. E., called at the Secretary's office on October 27 to pay his respects before leaving to take up his permanent residence in Paris, France, where he will be a special representative of the Crane Co. Mr. Lyon has been in Chicago for the past year or more, doing special work in the different departments of the Crane Company offices and factory, preparatory to taking up his work abroad. Most of his time for the past fifteen years has been spent in European countries and the near East.

Notice has been received that the Twenty-First Convention of the National Rivers and Harbors Congress will be held in Washington, D. C., December 9 and 10. Some of our members are interested in this Congress, which promises to be fully as interesting as those held in the past. Special rates on all railroads have been secured on the certificate plan, whereby the round trip may be had for the rate of one and one-half fare. Complete information can be obtained at the Secretary's office or by writing to the Secretary of the National Rivers and Harbors Congress, Room 824 Colorado Building, Washington, D. C.

The Fifth Annual Meeting of the Highway Research Board of the National Research Council will be held at Washington, D. C., on December 3 and 4, 1925. Progress reports received from the Chairmen of the Research Committees show that they are conducting important studies on almost every phase of highway development, including finance design, construction and maintenance thus assuring a successful annual meeting. The program for the Fifth Annual Meeting is now being prepared and will soon be announced.

While touring in Europe this summer T. L. D. Hadwen, M. W. S. E., had the pleasure of visiting with our old friend Baron G. A. M. Liljencrantz in Stockholm. Although the Baron is now past eighty years of age, he enjoys life and was pleased to hear from some of his old friends in the Society. He joined the Western Socity in 1878 and for many years was very active in its affairs while he was stationed here. He asked Mr. Hadwen to convey his greetings to all his old friends in Chicago. Mr. Hadwen reports that the Baron still enjoys good stories just as much as he did in the days when he was known as an excellent toastmaster at Western Society banquets.

Edgar S. Nethercut, Secretary, has been appointed a member of the Civic Industrial Clubs Committee of the Chicago Association of Commerce. This is the Committee which sponsors the work of the civic industrial clubs organized in all the High Schools throughout the City.

These civic industrial clubs are organized for the purpose of directing the enthusiasm and energy of the students along civic and industrial lines. Membership is voluntary and the dues are very small. The clubs are under the supervision of faculty members who cooperate with the students in directing the affairs of the club. The clubs carry on programs, including excursions to manufacturing and industrial establishments, talks by prominent business and profes-

sional men. Other activities include fire and accident protection, clean-up campaigns, charity work and local activities within the schools.

W. F. M. Goss, M. W. S. E., who has been president of the Railway Car Manufacturers' Association in New York since 1917, announces that he has retired to Barnstable, Mass., where he was born in 1859. He has been a member of the Western Society of Engineers since 1907 and served as Third-Vice-President durthe year 1909. Prior to his residence in New York, he was dean of engineering at Purdue University and was also at one time Professor of railway engineering at the University of Illinois. Dr. Goss has written a number of engineering books and has engaged in practice as Consulting Engineer.

Wallace R. Harris M. W. S. E. has resigned his position with the International Trade Press, Inc., Chicago, as managing editor of Highway Engineer and Contractor and of Concrete Products, papers covering industries in which Mr. Harris had experience as engineer and contractor. He assumes the position of sales manager for the Eberling Machines Sales Co., Cleveland, makers of modern equipment for the manufacture of concrete building units. Mr. Harris will have an office at 1248 Peoples Gas Building, Chicago. He was the first president of the Concrete Products Association and retired from this position after 5 years service.

Library Service

Your Membership card presented to the Librarian will entitle you to take books from the Library for a limited time. This service to members has increased the use of the Library in a most satisfactory way. Members must be identified and the readiest way is your membership card.

It is necessary to limit the time books can be out and the member is obliged to return the book promptly at the due date or secure an extensoin..

Members calling for books by messenger will please send note explaining the authority of the messenger.

This rule is made necessary due to the failure of members to return books and this constitutes a loss to the Library.

Book Review

"Codes of Ethics," A Handbook, by Edgar Heermance, Published by Free Press Printing Company, Burlington, Vt.. 1924, 520 pages and an "Index of Organizations."

This book is a collection and selection of "ethical codes" so called although many are really Standards of Practice or rules to guide merchants, manufacturers, and others in their business dealings. The author in his preface gives three reasons for publishing this collection: "First,. to facilitate the work of association officers in drafting or revising standards: second, to bring before leaders of public opinion the concrete evidence of a remarkable ethical movement, and third, to assemble case material for teachers of Ethics."

The table of contents lists 132 headings ranging alphabetically from Accounting to Warehouses and includes Advertising, Architecture, Building Construction, Engineering, Law, Medicine, Purchasing and Real Estate which may all interest engineers. The leading professional societies are represented as well as non-professional organizations. Written codes have been found most effective means of establishing fairly definite ethics or acceptable standards of practice. Unethical practices of individuals are a menace to society and jeopardize the standing of a group as a whole.

This book will serve a useful purpose to all who have occasion to study codes of ethics or to prepare or revise such codes for professional or non-professional organizations.

T. L. C.

Tests of Curved Boiler Heads, regarding their strength and deformation. "Versuche uber die widerstandsfahigkeit und die formanderung gewolbter kesselboden."

By C. Bach. A report by the material testing laboratory of the Engineering College, Stuttgart, Germany with nine test logs and 95 figures, 46 pages. Berlin 1925. Verein Deutscher Ingenieure. Bulletin No. 270.

A description of a series of tests with 16 convex boiler heads of different shapes and about 52 inches diameter, thickness 5/8 inch to 1 inch. The greatest stresses were ascertained in the curved rim, near the periphery of the heads. The elliptical heads showed in round figures three or four times the strength of the ordinary shapes. With increasing pressure all the heads showed a loosening of scale denoting the passing of the yield point of the material at the beginning of the curvature near the periphery. These very important and very interesting tests deserve the attention of boiler manufacturers and large users, all the more so as the author has done a great deal of original research work on this subject for over thirty years. The publication is further of importance to testing laboratories as the reports give all details of the tests in painstaking details and as the writer is also the author of a text book on "Elasticity and Strength of Materials."

Drawing operations of irregularly shaped hollow ware. "Das Zuiehen Unregelmsasig Geformter Hohlkorper."

By Dr. Ing. Hans D. Brasch. Berlin Verein deutscher Ingenieurs. Bulletin No. 268, 1925, 33 pages, 36 tables and diagrams.

The work was suggested by the manufacturers and the original investigations were intended for their practical purposes. However, in course of the investigations the necessity of fundamental and far-reaching work was found to give the results general value for the ever-changing requirements in the field of manufacturing Hollow Ware of thin gauge sheet metals. The subjects covered are:

Lack of economy of present methods.
Mechanical operations and methods of drawing processes.
Working requirements of drawing processes.
Examination of drawing tools and the results: Effect of depth of drawing. Shapes of preliminary operations. Friction. Finishing tools. Proportion of diameter and depth. Selection of number of operations. Determination of size of blank.
The design of drawing tools on the basis of previous examination.
Conclusions regarding other materials (iron). Manufacturing details. Standardizing of d awing tools.
Literary references.

H. G.

New Books

James S. Stephens, M. W. S. E. has placed fifty volumes on aeronautics in the Library of the Western Society. This is in addition to the eighty volumes Mr. Stephens has already sent us. This latest collection includes almost every kind of work on aerial navigation, the design and construction of aircraft and their operation. Mr. Stephens has made a distinct contribution to the members of the Society by making his Library available to all. This service is greatly appreciated.

Onward Bates, Hon. W. S. E., has given to the library the following volumes:

Los Angeles Aqueduct, Final Report.
Board of Water Supply of the City of New York City.
Report of Long Island Sources.
Report of the Chicago Traction and Subway Commission.
The McKinley Bridge, by Ralph Modjeski.
The Delaware Bridge, by Ralph Modjeski.

He has also loaned to the library, two volumes containing reports of the Chicago Bureau of Public Efficiency for the Years 1911-1917, during which years he was a member of the board of trustees.

The descriptions of the McKinley Bridge and the Delaware bridge by Modjeski are in his customary form and will prove to be of great interest in view of the fact that the Delaware bridge is only now approaching completion.

510.8
L147 g

A Graphic Table Combining Logarithms and Anti-Logarithms. Adrien Lacroix and Charles L. Ragot. New York, MacMillan, 1925. 66pp.

A novel presentation of numbers and their logarithms in such a way as to eliminate the need of interpolation. Two tables are included, one giving 4-place logarithms for numbers of 4-figures, and one giving 5-place logarithms for numbers of 5 significant figures.

620.1
A512p

American Society for Testing Materials Standards Adopted in 1925.

Published by the American Society for Testing Materials, and contains standards adopted since publication of the triennial volume. A second supplement will be issued in 1926 and the next triennial volume of standards will appear in 1927. This pamphlet may be obtained upon payment of $1.50.

670.2
C517

Chemical Engineering Catalog.

A catalog of materials and machinery used in manufacturing establishments which employ chemical processes. Both materials and machinery are classified together under subject and separately by the alphabet in two divisions, Machinery, and Chemicals and Materials. Following this is a very valuable book list of technical books.

623.806
N874

North East Coast Institution of Engineers and Ship-builders. Transactions 1924-1925. vol. 41.

A collection of papers on engineering subjects which have been read before the N. E. C. I. of E. & S. during the last year's meetings. While British practice is not always pertinent to American engineering work, the papers themselves have a high value from a scientific standpoint.

L. Reeves Goodwin, M. W. S. E., has recently been made Vice-President of A. E. White & Company, 19 So. La Salle street. This Company is interested in industrial engineering, financing and operation and certified audits. Mr. Goodwin has had the rare combination of financial and engineering training, which fits him for the responsibility of such a position.

Employment Service

With this issue of the Journal we resume a practice which was discontinued several years ago, in connection with the Employment Service. The new Employment Service is now functioning in co-operation with the four Founder Societies. The attention of employers is directed to the following members of the Western Society of Engineers, who are available.

Members may register with the Employment Service, Room 1736, Monadnock Block, where information about positions open may be obtained.

34—**Sales Engineer:** Grad. in M. E. and E. E. Wide experience on power plant equipment and supplies.

64—**Electrical Draftsman:** Age 29 years, single. B. S. in E. E. 1 year's experience in power plant work.

93—**Valuation Engineer:** Age 33 years, married, grad. C. E. 10 years' experience in industrial properties for firm of engineers and accountants.

160—**Building Engineer:** Age 36 years, married, grad. C. E. Broad experience in building construction and design, also in handling help.

166—**Municipal Engineer:** Age 27 years, single, grad. C. E. Broad experience in sewer construction, railroad and townsite surveys, roads and drainage.

168—**Construction Engineer:** Age 43 years, married, grad. Broad experience. Capable building superintendent or office manager for contractor or architect.

174—**Construction Foreman:** Age 40 years, single, B. S. in M. E. Experience in handling labor on building construction.

172—**Instrument Man and Draftsman:** Age 26 years, single, grad. C. E. 5 years' experience in structural drafting, railroad maintenance and building construction.

179—**Combustion Engineer:** Age 28 years, married, M. E. grad. Experience in boiler inspection.

194—**Geodetic Surveyor:** Age 31 years, single, C. E. grad. Experience in railroad and highway surveying, bridge design.

195—**Draftsman:** Age 26 years, single, B. S. M. E. Experience in plumbing and heating layout.

196—**Sales Engineer:** Age 27 years, single, B. S. E., M. E. grad. Experience in building construction, office management.

200—**Surveyor and Draftsman:** Age 25 years, single, C. E. Experience in building construction and drafting.

201—**Technical Advisor and Development Engineer:** Age 24 years, B. S. M. E. Experience in production work in manufacturing plants.

206—**Construction Draftsman and Surveyor:** Age 20 years, C. E. grad. Experience in drafting and instrument work.

223—**Sales Engineer:** Age 47 years, married, grad. engineer Corps. Experience in power plant equipment and general manufacturing experience.

234—**Chemical Engineer:** Age 38 years, married, technical education, broad experience in industrial chemistry.

252—**Building Engineer and Designer:** Age 39 years, grad. Architect. Engineering, 9 years' experience in reinforced concrete and structural designing.

256—**Mechanical Draftsman:** Age 34 years, single, technical grad. Norway. Experience in heating, ventilating and power plants.

APPLICATIONS FOR MEMBERSHIP

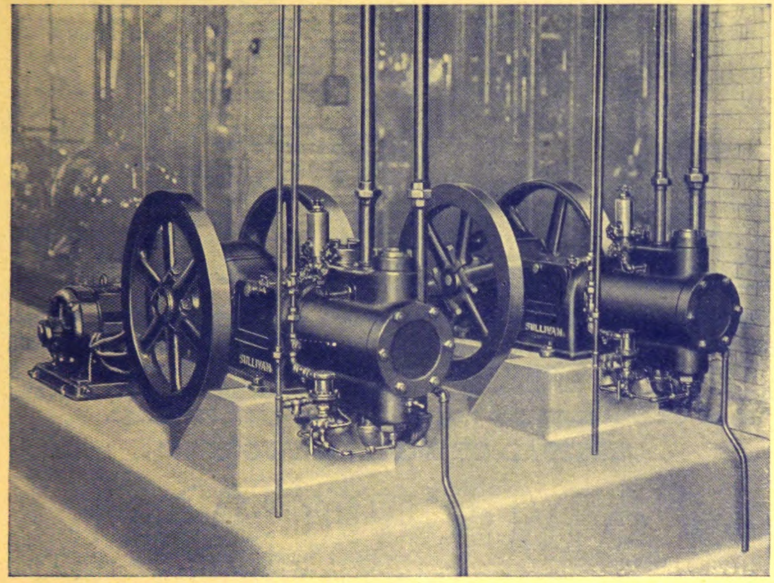
Members of the Society can be of great service if they will make a practice of examining the list of applicants published herewith and promptly notifying the Membership Committee or the Secretary regarding the qualifications of any of those whose names appear on the list. The Society desires to extend its membership and receive those engineers who have the proper qualifications and wish to participate in its activities. The following applications have been received since last report:

No.	Name	Address
200	Fenton L. Howard,	2154 Lawrence Ave., Chicago, Ill.
201	Walter K. Cook	1016 Second Ave., Joliet, Ill.
202	Cecil Hodgson	Public Service Co., 72 W. Adams St., Chicago
203	Frank E. Brown (Trans.)	Room 1400 Monroe Bldg., Chicago
204	Clement C. Williams	University of Illinois, Urbana, Illinois
205	Philip C. Weicker	3358 No. Ashland Ave., Chicago
206	Norbert R. Thornton	1516 N. Kedzie Ave., Chicago.
207	Harry M. Engh (Tra	American Appraisal Co., Milwaukee, Wis.
208	Charles A. Crane, Jr	Templeton Kenly & Co., Ltd., 1020 S. Central Ave., Chicago, Ill.

NEW MEMBERS

The following were elected to membership in the grade indicated by the Board of Direction, at its meeting held September 21, 1925.

No.	Name	Address	Grade
144—1925	Robert E. Andrus (Trans.)	Box 174, Oak Park, Ill.	Associate
147	Carl W. Johnson	5054 W. Patterson Ave., Chicago	Junior
196	C. F. Boake	53 W. Jackson Blvd., Chicago	Associate



A little air all the time is the guarantee that goes with

Sullivan "WG-6"
Small Belt Driven Compressors

Sullivan air power engineers have made the "WG-6" compressors sturdy, dependable, almost automatic, so simple that they are seldom "out of order," but with the same quality built into them in design, in materials, and in painstaking workmanship that distinguishes the largest and most costly Sullivan compressors.

The cut shows Sullivan "WG-6" Compressors in the Union Bank Bldg., Pittsburgh, where they are called upon for constant, unremitting service.

Hundreds of new "WG-6's" are installed every year, and give their owners steady, dependable service, in the mine, the foundry, the workshop, or on the construction job.

Capacities, 68-500 cu. ft.

New Bulletin 2077-K

SULLIVAN
MACHINERY COMPANY
122 So. Michigan Ave. Chicago.

JOURNAL of the WESTERN SOCIETY of ENGINEERS

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JOURNAL OF THE
WESTERN SOCIETY OF ENGINEERS

Volume XXX NOVEMBER, 1925 Number 11

A Letter to the Members

December 10, 1925.

The unique contribution made by Past President Onward Bates to the Western Society (see below) originated in his mind as the expression of a long-cherished desire to do something in a practical way to promote the interests of the Society and to increase its usfulness to the membership.

Many of our distinguished members, especially those who have achieved substantial success, will doubtless desire to participate in this voluntary financial support for special purposes of our Society work. Mr. Bates has opened the way and the "Directors' Annual Special Purpose Fund" provides the medium through which others may share in the promotion of particular projects which cannot be undertaken without the additional funds which will be most welcome for the furtherance of this plan. This fund will be expended for such specific purposes as the Board of Direction may decide upon from time to time. Additions to our library, increasing its facilities and service, better facilities and equipment for our technical meetings, and improved service to members are some of the purposes under consideration for immediate utilization of the funds now in hand. This splendid idea of Mr. Bates, adopted by others, continued and well executed will greatly augment the value and increase the service of our Society to its membership.

HOMER E. NIESZ,
President.

Sets Up a New Idea

The Secretary received the following letter from Dr. Onward Bates, Honorary Member W. S. E. This letter sets up a new idea and is extremely interesting.

November 4, 1925.

Mr. Edgar S. Nethercut,
Secretary, Western Society of Engineers,
1735 Monadnock Block,
Chicago, Illinois.

Dear Mr. Nethercut:

"One day in the last century I received a call from two members of the W. S. E. who informed me that the Society was in urgent need of funds for running expenses and asked me to make a subscription. I replied that I was a comparatively new member of the Society and my business was such that I could not attend the meetings except on rare occasions, in fact, I did not know what good the Society was to me and it seemed to me it was sufficient if I paid my dues and I might be excused from making a special contribution. The spokesman for this committee, who had a very pleasing manner and whom I wish I could see oftener than I do, replied that I had given them the best reason for subscribing to their deficiency, to-wit: If I did not attend the meetings or show any interest in the Society other than to pay my dues I was just the member who should make up for my shortcomings by giving them some money. At that time the statement brought a new idea to me. I had not taken that view of it before, but I recognized the logic of it and, of course, subscribed. It taught me a lesson and has come back to me many times since that occasion.

"I will not undertake to say what I think of the Western Society, other than it is the best of all the local associations and it has its place. Every engineer who is qualified for membership and resides in Chicago, or for that matter anywhere else, ought to join the Society and should recognize its value and the reciprocal duties between the Society itself and its membership. This would be for his personal profit, for the advancement of his profession and for good citizenship. It is apparent that the Society cannot exist without the support of its members. If it were supported by outsiders it might exist but it would lack those things which

are most essential for its welfare and its usefulness. Running expenses should, therefore, be paid by the membership. Every member should pay his dues. These dues should be so small as not to be a burden upon any member. All this is for the general fund of the Society, but the Society can use to advantage more money than is covered by the annual dues—perhaps it needs more money to maintain its usefulness. I have been thinking over this problem for a good while without being able to advocate any particular plan covering what is in my mind, but I will venture to open my mind to you with the hope that your officers can improve on the suggestions I make and formulate them to the advantage of the Society.

"Some of our members have set us a splendid example of loyalty to the Society and zeal for the profession, including our social fellowship. I have in mind at this moment those two members who established the Chanute medal and the Washington award. I have a desire to emulate them although not in so liberal a manner nor on just the same lines. I fully believe that members as they prosper should increase the income of the Society, not by payment of dues but by voluntary donations over and above their regular dues. As we get better established and perhaps make some money, we ought to remember our Society as, if not our Alma Mater, perhaps a step-Alma Mater. Outside of our membership there may be friends of the Society who would like to affiliate themselves without incurring obligations by donating to such a fund as I have in mind. I do not know what you would call this fund but since it is intended to supplement the regular income of the Society for general purposes, I think perhaps a good name would be the "Directors Fund," for the reason that we choose good men for our Board of Direction and they are in a position to decide and handle the proceeds of any such fund better than even its donors could. It seems to me that the Society's annual statement might have an item of "Donations to the Directors Fund," giving the gross amount received during the current year and a list of the donors by name, without any reference to the amount of their individual donations. The directors would appropriate the contents of this fund each year for any purpose which to them seemed good for the Society without any instructions or restrictions from the donors. This fund would never be a large one, it would be wiped out every year, but if there was the opening for members who have paid their dues and other friends to make donations, no one can tell what the annual amount would come to. I do not know that any particular harm would be done if this game was a failure. In any event, it would bring in some money, at least at the outset, for I have made up my mind that I wish to give the Society the sum of five hundred dollars (for expenses—not to build a 52-story building or anything of that sort). I prefer to make this donation in a lump sum because, as you are aware, I have come to that period when I cannot figure on years ahead of me. Of course, donors may give as often as they please, but in my case it is quite likely my first donation will be my final one.

"I wish you would take this up with your Board of Directors as a suggestion —not as a recommendation—and when they have considered it, advise me if they will accept my donation and upon what terms."

Yours truly,

(Signed) ONWARD BATES.

On being advised of the action of the Board of Direction Dr. Bates tendered his check for $500.00 and said he was gratified to know that his suggestion was received favorably by the Board and he was entirely satisfied to place the suggestion before the members of the Society. The President was authorized to appoint a committee to consider means and methods of securing additions to this fund and to recommend the purpose of such a fund. The committee consists of C. A. Morse, F. K. Copeland and H. E. Niesz.

Demonstrates Factory Lighting

November 2 was a meeting a little out of the ordinary for a technical program in that it was a dinner meeting held at the Electric Club. The subject was "Relighting Chicago's Factories."

This was a joint meeting with the Chicago Section, Illuminating Engineering Society. Immediately after dinner a motion picture showing the advantages of proper illumination in factories was shown. This film contrasted new and old methods of lighting and the improvement in production and safety to employees was clearly brought out.

Next on the program was a demonstration of different kinds of lighting units used for factory illumination. The

speaker who had been scheduled to present this demonstration was unable to be present and it lacked some of the force that it might otherwise have had.

There was also a little sketch supposed to represent the advantages of calling in an experienced illuminating engineer to solve the problem of securing proper illumination.

Use of Hooks in Reinforced Concrete

A meeting full of interest from start to finish was held, November 9, when Prof. T. D. Mylrea, Assistant Professor of Structural Engineering at the University of Illinois read a paper on "Use of Hooks in Reinforced Concrete."

This is a subject which is not so very well understood among Designing Engineers and there are a number of forces which are rather difficult to determine. He first reviewed some of the elementary determinations in reference to bond between concrete and reinforcing bars. He illustrated his address throughout with lantern slides and derived a number of the formulas on the blackboard, explaining how they should be applied.

Prof. Mylrea paid particular attention to the methods which may be employed to prevent splitting of concrete due to improper treatment of the reinforcing. The most interesting part of this meeting was the discussion which followed the presentation of the paper.

Before the meeting the Junior Engineers took advantage of Mr. Mylrea's presence to invite him to their regular meeting at 6:30 and engaged in a half hour of discussion across the table. It would be hard to say whether either side enjoyed it more than the other, but it is certain that both the speaker and his hearers got a great deal of good out of it.

Willis Rabbe who was in charge of employment and various other assignments in the office of the Secretary of the Western Society for one year and a half, left Chicago December 1st on a six month assignment in Louisiana. He is now employed by Thompson and Lichtner, Industrial Engineers of Boston and reports that he is enjoying his new connection very much.

Waste Heat Furnishes Power

"Utilization of Waste heat in Steel Mills" was the subject of our meeting, November 16th, held jointly with the Chicago Section, American Society of Mechanical Engineers. E. H. Wilcox, Vice President, Freyn Engineering Co., was the speaker and presented an excellent paper, describing the remarkable success in some recent installations of waste heat boilers of the fire tube type.

In the consideration of a boiler for the recovery of heat in waste gases there is a fundamental difference as compared to direct-fired boilers, because the temperature of the gases from which the heat must be extracted is less than twelve hundred degrees fahrenheit, whereas furnace temperatures of more than twenty-seven hundred degrees are available. For this reason rapid circulation of water is not so important as the maximum heat recovery which can be accomplished only by the most intimate contact of gases and water heating surface. This determines the use of small tubes in a fire tube boiler or close spacing of tubes in a water tube boiler. It also requires the use of artificial draft. Mr. Wilcox analyzed these factors and showed how they effect the design of boilers and the results that are accomplished by giving these elements proper consideration.

His paper went into the details of boiler cleaning, maintenance, boiler settings and auxilaries. Test results quoted showed that forty percent of the value of the fuel fed to open hearth furnaces was recovered in the form of steam by waste heat boilers.

A similar application is on cement kilns where a large amount of energy can be recovered from the heat wasted in the escaping gas. Another interesting development is the use of waste heat boilers for recovering the heat from the exhaust gases of internal combustion engines. With the growing popularity of Deisel engines, this development is assuming large proportions. Approximately thirty percent of the heat value of the fuel is lost in the exhaust gases. By utilizing the waste gases in a suitably designed boiler and also using a portion of the hot cooling water for heating boiler feed, the total lost heat is reduced to about

eleven percent and the percentage of useful work extracted from the fuel is increased from thirty-three percent to forty percent. This recovery is quite worth while in large size Deisel engines and those operating on producer or blast furnace gas.

In the discussion of this subject there was a very keen interest shown in the experience with water tube as compared to fire tube boilers. It appears that most of the difficulty in the operation of either type has been overcome, so that installations of both kinds may be depended upon.

I. C. R. R. Will Use Mercury Rectifiers for Power

The largest crowd that has attended a meeting in the rooms of the Society this fall greeted L. T. Robinson, of the General Electric Co., Schenectady, N. Y., November 23, when he presented his paper on "Mercury Arc Rectifiers." This was a joint meting with the Chicago Section, American Institute of Electrical Engineers and it taxed the facilities in our rooms to the limit, but the interest in the subject was such that comparatively few left before the end of the meeting.

The progress that has been made using rectifiers for heavy power requirements in Europe for the past several years is well known. The fact that Chicago has one of the first installations of these devices on a large scale in America, has excited the interest of local engineers. There are two rectifiers now in service on the lines of the Commonwealth Edison Co., and about one-fourth of the power to be furnished to the Illinois Central on its new electrification will be converted by this means.

Ability to sustain high overloads, the absence of moving parts, ease of operation and maintenance and simplicity in production of high voltage direct current were some of the factors which decided the engineers of the Commonwealth Edison Co. and the Illinois Central Railroad to install rectifiers in a part of their substations. Operating conditions in this installation will be specially severe and if the mercury arc rectifiers are successful here, they will probably be satisfactory for any other location.

There was a very complete and interesting discussion of this subject, following the presentation of the paper. In this Mr. Robinson was very gracious in answering questions and giving information based on his own intimate contact with the development of these rectifiers which have been in process for nearly twenty years.

By-Products Recovered in the Gas Industry

The recovery of by-products may not always be a direct profit, as shown by Chester S. Heath, M. W. S. E. Chemical Engineer of the Peoples Gas Products Corporation in his paper before the Society on November 30th. The products to be recovered from gas fall into sixteen major classifications, which were enumerated and outlined in this paper.

Mr. Heath described the processes of recovering a few of the more important products, such as light oil, different kinds of tar, motor fuel, ammonium sulphate and others. There are some products which the company is required to remove from the gas for the protection of its own equipment, rather than because of their value. For instance, there are some kinds of gum taken out of the gas which if allowed to remain in it, would clog up the meters and governors resulting in a great deal of trouble in operation. Also certain oils precipitate out of the gas in transmission and would have to be removed from the mains in the streets by laborious process. There are certain other products which if removed from the gas effect its value or quality and therefore are better not removed.

This paper described the processes of recovering the more important by-products in a modern gas plant. Coal tar is removed by a system of coolers and condensers. The derivatives of coal tar run up into the thousands and it was obvious that Mr. Heath could not undertake to describe them in one paper. Another product recovered is ammonium sulphate which is used for fertilizer. This requires other special apparatus.

Before gas can be sent out it must be passed through a light oil recovery plant, which takes out the oil, which

would otherwise precipitate in the holders and street mains. Coincident with the recovery of light oil, other parts are taken out such as napthaline which has little value but would cause serious and expensive stopping of mains and apparatus if allowed to remain in the gas. The light oil yields a variety of products ranging from motor fuel to sugar substitute and including such things as explosives, dyes, drugs, etc. Mr. Heath described a number of the processes and equipment required in the recovery of some of these products. His paper was illustrated by lantern slides and was very instructive.

New Victrola Heard at House Warming and Smoker

In spite of the cold rainy weather, there was a goodly number of our members who turned out in response to an invitation from the Entertainment Committee to attend an informal House-Warming and Smoker in our rooms, November 12. There was no formal program announced for this evening, but a general invitation was extended to all the members to come up and get acquainted with the new arrangement and listen to some music.

Through the courtesy of one of the local music houses, we were given a demonstration of the new orthophonic victrola, which had just been announced. This instrument reproduces a much wider range of musical sound than the models which have been in use for many years past. A representative explained the construction of the new instrument and told what had been accomplished in its design. Heretofore it has not been possible to reproduce musical tones, having a frequency of less than about 300 or more than 1200, but the new instrument brings out everything over a range of 113 to over 12,000 vibrations per sceond. This means that it reproduces all the bass notes, as well as the over-tones and the higher notes. The speaker who demonstrated the instrument told how the research was conducted in connection with the laboratories of the American Telephone & Telegraph Co. and the Victor Talking Machine Co. working jointly on this problem. He then played a number of selections on the old style instrument and then by way of comparison played them on the new instrument to demonstrate the difference in volume and quality of tones. This concert lasted for an hour or more and was greatly enjoyed.

Refreshments of cider, doughnuts, fruit punch and cookies were served throughout the evening and a plentiful supply of cigars and cigarettes was on hand.

Inspect Crawford Ave. Station

Saturday, November 28th, was chosen as the date for the excursion to the Crawford Avenue Power Station of the Commonwealth Edison Co. This date was selected to avoid any conflict with football games in Chicago, or with Christmas shopping. The weather was ideal. Reservation cards were sent out to the members, asking them to reply, indicating whether they would attend. Nearly two hundred of these cards were returned by the members, but only one hundred twenty of them actually put in their appearance at the train and about thirty more drove out. This proved to be something of a disappointment as luncheon had been prepared for more than two hundred. It is this kind of lack of support, that makes our Committees wonder whether it is worth while to go through all of the trouble of arranging events for the benefit of the members.

The Commonwealth Edison Co., furnished a special train, which left the Van Buren St. Station of the Illinois Central Railroad at 12:10 and went directly into the plant. The first thing inspected was the coal handling equipment and storage facilities which have capacity for storing one hundred thousand tons of coal. Coal can be unloaded at the rate of fifteen cars per hour and conveyed either to the storage yard or to the breakers where it is prepared and sent on to the boiler room.

The next point visited was the outdoor transmission station designed to accomodate seven 15,000 kilowatt transformers, with necessary switching arrangements. Energy is received from the station at 12,000 volts and transformed to 22,000 or 33,000 for transmission to other stations. After inspecting the screens at the intake to the circulating water system,

the party was conducted to the main building, where luncheon was served.

After luncheon the guests were conducted to the operating gallery for inspection of the apparatus used for the control of the equipment in the station and for a general view of the Turbine Room. From here they were conducted through the Switch House to the Turbine Room where the three large generating units now in service were inspected. Next in order was the boiler room which is a model of cleanliness and efficiency. The record for this station is approximately one kilowatt-hour of energy for one and one-half pounds of ordinary Illinois coal.

This station when completed will have a capacity of seven hundred fifty thousand kilowatts or a little more than sixty percent of the entire power development in the Niagara Falls district. The operating force for the entire station will be only one hundred seventy-five men per twenty-four hour day of three shifts. Detailed description of the ash handling equipment, turbo generators, governors, switching equipment, exciters, switch house, reactors and switches, test cabinets, control panels, etc., all of which were inspected, would not be possible in the space of this article.

As soon as the inspection was completed, the party returned to the special train which had been switched to the track in front of the main entrance, returning to the Van Buren St. Station at about 4:00 P. M.

The courtesy of the Commonwealth Edison Co., in furnishing this inspection without cost to the members or to the Society is greatly appreciated. Our only regret is that more of the members did not keep their promise to take advantage of it.

See South Water Street Improvement

Those who attended the excursion of the Society to the South Water Street Improvement on October 24, realized that it is a much larger undertaking than they had suspected Ever since building operations commenced it has been the desire of the Excursion Committee to give the members a chance to inspect the project at whatever time it could be seen to the best advantage. This was found to be late in October when some of the sections were completed, while others were still in the early stages of construction.

F. J. Herlihy, M. W. S. E., President of the Mid-Continent Construction Co., which has the contract for several of the sections of this project, acted as host and had an excellent construction job to display to his guests. He was assisted by T. A. Evans, Designing Engineer, Board of Local Improvements and twelve of the representatives of that department who also acted as guides.

The outstanding feature of the whole thing was the concrete mixing equipment by which accurate control over the concrete going into the structure is maintained. This is largely possible through the use of a patented device, known as the inundator which measures the sand under water and permits accurate control of the amount of water going into the mix. It was a revelation to see the enormous amount of form work required for this job and the careful way in which it is done. The reinforcing steel necessary was also quite a sight The party was conducted over the entire improvement, the west end of which is practically completed.

A. A. A. S. Meets in Kansas City

The Annual Meeting of Section M (Engineering) of the American Association for the Advancement of Science will be held at Kansas City, Mo., Wednesday, December 30. Dr. C. R. Richards, President of Lehigh University is Chairman of this Section and will preside. Dr. Richards was a member of the Western Society for many years and will be remembered as the speaker at some of our meetings during the time he was at the University of Illinois.

The Engineering Section of the A. A. A. S. serves as the connecting link between the Association which is a great central clearing house for contribution to the knowledge of pure science and the professional engineering societies. It is hoped to develope closer operation between these two forces.

The speakers who are to appear on the program are: Dr. A. E. Kennelly, Pro-

fessor of Electrical Engineering, Harvard University; Col. E. Lester Jones, Director of the U. S. Coast and Geodetic Survey; James B. MacElwane, St. Louis University; Dean Hugh Miller, George Washington University; John Lyle Harrington, Past President of the A. S. M. E.; Dr. Michael I. Pupin, President, A. A. A. S. and A. I. E. E.; Dr. F. B. Jewett, Director of Bell Telephone Research Laboratories; Lee B. Roberts, Ernest E. Howard and Major Gee of the U. S. Engineers, and Dr. Roy Cross.

Harold J. McKeever who became an Associate member of the Society, November 16th, left Chicago on December 1 to take up a new position as Editorial Assistant for the Armco Culvert and Flume Manufacturers' Association at Middletown, Ohio. His work will be mostly in connection with the "Highway Magazine."

H. M. Spahr

H. M. Spahr, Division Enginer, C. & N. W. Ry., at Green Bay, Wisconsin, died October 29, at the age of fifty-one years. He was graduated from Purdue University in Civil Engineering in 1897, and spent almost his entire life in railroad and bridge construction. He was engineer in charge of construction of a number of the large railroad bridges in the middle west including bridges at Neenah, Menasha and Buffalo Lake, Wisconsin, the Illinois River Bridge at Pekin, Ill., Milwaukee River at Milwaukee, Wis., Chicago River at Deering and many others. He had charge of the construction of the ore dock and yards of the C. & N. W. Ry. at Ashland, Wis., and during the war was engineer of capital expenditures U. S. Railroad administration. After the war he was appointed Division Engineer at Green Bay, Wis., which position he held until his death.

Virgi G. Marani

Virgil G. Marani, M. W. S. E. Chief Engineer of the Gypsum Industries, 844 Rush street, Chicago, died suddenly at his home in Evanston, November 2, 1925. He was stricken with a hemorrhage of the brain, as he was taking his car out of the garage at his home, and collapsed. He never regained consciousness.

Mr. Marani was born in Reggio in the province of Emilia, Italy, July 4, 1868. He graduated in 1893 from Toronto University and was placed in charge of the sewage disposal and waterworks being constructed at Brantford, Ontario. From 1894 to 1896 he was Assistant Engineer of the Cleveland Department of Public Works and was Chief Engineer of the Cleveland Gas Light & Coke Co., until 1907. Following this he engaged in private practice for three years and was superintendent of construction of a five-million-dollar courthouse. Following this he was made Building Commissioner of Cleveland and then became Chief Engineer of the Gypsum Industries. He served on the War Service Committee on Gypsum during the World War.

Mr. Marani was a member of the American Society of Civil Engineers, American Society for Testing Materials, American Association of Engineers, Cleveland Engineering Society, National Fire Protection Association and the Western Society of Engineers. Services were held at his home in Evanston and interment was at Cleveland, Nov. 4.

Ira O. Baker

The Western Society lost one of its honored members when Dr. Ira O. Baker, Professor Emeritus of the Department of Civil Engineering at the University of Illinois died Sunday, November 8, at Rochester, Minn., following a second operation for an intestinal trouble.

Prof. Baker was born in Linton, Ind., in 1853, and was married in 1877. His first wife died in 1911 and he was married again in 1913. His wife, a daughter and two sons survive him. Dr. Baker and Mrs. Baker went to Rochester in October for the treatment of Mrs. Baker. While there, Dr. Baker submitted to a minor operation and was apparently recovering successfully when physicians decided that a second operation was necessary. It was thought that he would recover from this second operation satis-

factorily, but his death came suddenly.

Dr. Baker graduated from the University of Illinois in 1874 in the third class to graduate from the University. He immediately took up work as an Assistant Instructor in Civil Engineering and became head of that department in 1879.

In 1886 he organized the Illinois Society of Engineers of which he was president for two years. He organized the Congress on Engineering Education held in connection with the Columbian Exposition in Chicago and was Chairman of that Congress.

Dr. A. N. Talbot, M. W. S. E. has been appointed a committee to prepare a suitable memoir for Prof. Baker, which will be published in a later issue of the Journal.

APPLICATIONS FOR MEMBERSHIP

Members of the Society can be of great service if they will make a practice of examining the list of applicants published herewith and promptly notifying the Membership Committee or the Secretary regarding the qualifications of any of those whose names appear on the list. The Society desires to extend its membership and receive those engineers who have the proper qualifications and wish to participate in its activities. The following applications have been received since last report:

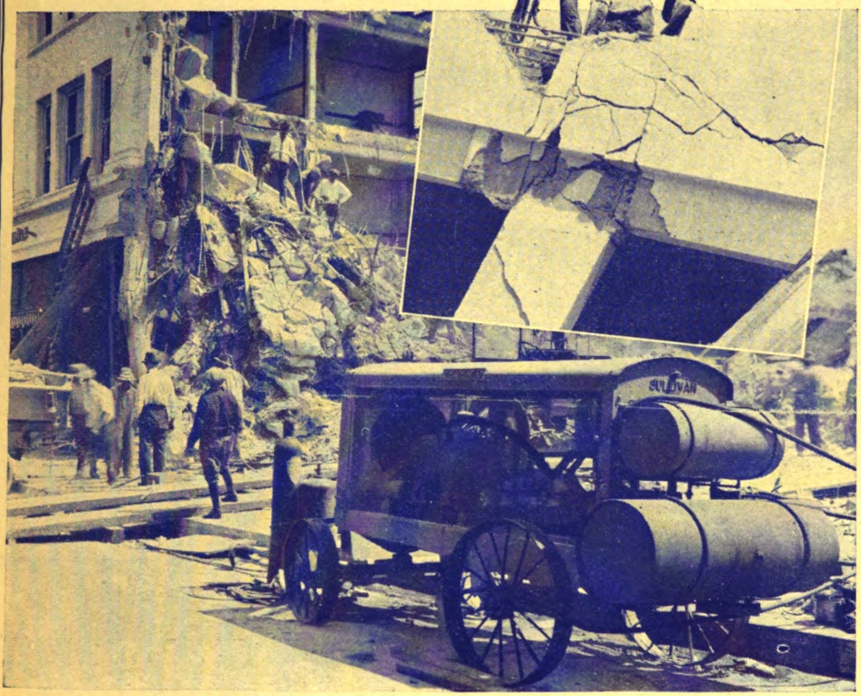
No.	Name	Address
209	Edwin Zeleny	373 Forest Ave., Glen Ellyn, Ill.
210	Howard D. Harvey	553 S. Locust St., Valparaiso, Ind.
211	Ralph J. Dodds	3219 S. Michigan Ave., Chicago, Ill.
212	Herbert C. Kukral	3219 S. Michigan Ave., Chicago, Ill.
213	Edward J. Hauer	Illinois Central R. R., Rm. 706, Chicago, Ill.
214	Samuel K. Brown	3210 Arthington St., Chicago, Ill.
215	Harold J. McKeever	7255 Evans Ave., Chicago, Ill.
216	Harold E. Wessman	5808 South Park Ave., Chicago, Ill.
217	Robert M. Stull	2514 Prairie Ave., Chicago, Ill.
218	John W. Rowley	1243 Railway Exchange Bldg., Chicago, Ill.
219	Robert P. Petersen	4118 N. Parkside Ave., Chicago, Ill.
220	Robert F. Lyons	118 E. 26th St., Chicago, Ill.
221	Meyer Louis	1855 S. Troy St., Chicago, Ill.
222	Lawrence H. Heit	112 S. Maple Ave., Oak Park, Ill.
223	Louis N. Hitchcock	7412 Vincennes Ave., Chicago, Ill.
224	William T. Blunt	D. P. Davis Properties, St. Augustine, Fla.
225	Lotan C. Read	Sandusky House, Sandusky, Mich.
226	Scott R. Conwell	456 Deming Place, Chicago, Ill.
227	John F. Rithmiller	456 Deming Place, Chicago, Ill.
228	L. B. Kerdell	2639 Armitage Ave., Chicago, Ill.
229	Charles H. Clinton	6204 S. Park Ave., Chicago, Ill.
230	H. B. Palm	2140 Burling St., Chicago, Ill.
231	Donald J. Braden	6237 Ingleside Ave., Chicago, Ill.
232	C. G. R. Johnson (Trans.)	507 Chatauqua Ave., Norman, Okla.
233	Otto Breuk	118 E. 26th St., Chicago, Ill.
234	John W. Webster	113 Jersey Ave., Joliet, Ill.
235	Raymond S. Knapp (Transfer)	11066 S. Irving Ave., Chicago, Ill.
236	Charles M. Davison	5 S. Grant St., Hinsdale, Ill.

NEW MEMBERS

The following were elected to membership in the grade shown by the Board of Direction at its meeting October 19, 1925:

No.	Name	Address	Grade
141	Hilford G. Nelson	4455 Grand Blvd., Chicago, Ill.	Junior
199	H. T. Moorman	1725 Wilson Ave., Chicago, Ill.	Associate
202	Cecil Hodgson	% Public Service Co., 72 W. Adams St., Chicago, Ill.	Member
203	Frank E. Brown (Trans.)	1400 Monroe Bldg., Chicago, Ill.	Member
204	Clement C. Williams	University of Ill., Urbana, Ill.	Member
205	Philip C. Weicker	3358 N. Ashland Ave., Chicago, Ill.	Junior
206	Norbart R. Thornton	1516 N. Kedzie Ave., Chicago, Ill.	Associate
208	Charles A. Crane, Jr.	1020 S. Central Ave., Chicago, Ill.	Member

Compressed Air Helps Santa Barbara Clean Up



After the earthquake, the big job at Santa Barbara was to get rid of the wreckage and clear the ground for rebuilding.

The San Marcos Building, the largest office building in the city, was partially destroyed. Compressed air speeded up the work of clearing away the wreckage and demolishing the cracked and distorted members of the structure.

Concrete Breakers rapidly tore out the reinforced concrete floors, columns, and walls, to make ready for rebuilding. Air was supplied by a Sullivan WK-314 220-ft. portable compressor, which was readily moved from place to place about the building, and the work of demolition progressed.

Sullivan Portable Compressors and Compressed Air Tools, Rotators, Busters, Spaders, enable you to "Do it Quicker with Air," whether its cleaning up after an earthquake or any construction or repair job of a normal or emergency character.

Ask for new Portable Compressor Bulletin 2077-N

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Power Conference Is the Last Week In January

Two outstanding events on the January program are the meetings of January 11 and the Midwest Power Conference which is to be held the last week of the month, in which the Society is to participate. The detailed program is printed on another page. The other two meetings are of equally high caliber but more limited appeal.

Flow of Power in Electrical Machines

One subject that will appeal to all engineers who are interested in the fundamentals of power transmission will be interested in the meeting January 11 which is to be addressed by Dr. J. Slepian, Research Engineer of the Westinghouse Electric & Manufacturing Company of East Pittsburgh, Pa. This will be a scientific lecture touching one of the subjects which has never been understood. Dr. Slepian will explain the theory that power is transmitted through the space, immediately around an electrical conductor, rather than through the copper conductor itself. He will trace this analysis in the applications of the theory to transmission lines, transformers, induction motors and synchronous generators.

This theory is by no means a new one, as it is based upon principles that were known forty or fifty years ago. By the use of these principles, Dr. Slepian will undertake to explain some of the fundamental theories that are not well known even among electrical engineers.

This is to be a joint meeting with the Chicago Section, American Institute of Electrical Engineers.

Economics of Grade Reduction

Chas. A. Morse, Past President, W. S. E. Chief Engineer, Chicago Rock Island & Pacific Railway Co., is to be the speaker on Monday, January 18, at which time he will present a paper on "Economics of Grade Reduction vs. Reduction in Mileage." This is a paper on which Mr. Morse has been working for many months and is based upon the studies that he has made as to whether it will be more economical to reduce grades on the present lines or to build a new line of shorter mileage.

Railroad engineering has changed entirely in the past generation and now involves these larger questions of economics. The pioneering is all done and it is now a question of rebuilding the railroads to operate on the most economical basis possible.

While this meeting is of most interest to railroad men, yet it is an example of the application of the same fundamental principles which must be recognized in analyzing any engineering project on an economic basis. For this reason it will appeal to many engineers in other lines of work.

Will Review Engineering Education

In planning the program of technical meetings for this year, no meeting was scheduled to be held on January 25, because of the fact that the Society is taking part in the Midwest Power Conference which will hold meetings during that week, which will be of a highly technical nature.

When Gerard Swope, President of the General Electric Co., addressed our Noonday Luncheon in December, he made a statement that the engineers owe a definite debt to posterity which they should discharge by co-operating to the fullest extent in the education of the coming generation of engineers, just as they have in turn profited by the experiences of those who have gone before. He said that the Western Society might well have a committee studying the subject of engineering education.

This thought suggested to our Junior Engineers that they, being the most interested in education, might take it up as a subject for discussion. Accordingly the Junior Engineers are arranging to present a program on January 25 on the general subject of the continuation of the Engineer's education after he finishes school. It is planned to have three or four speakers, particularly qualified to speak on the subject from different viewpoints, give short addresses. At this writing the definite subjects and names of speakers are not actually settled, but it is planned to have one representative from an engineering school, one representative from large industries which are particularly interested in the education of the engineers coming into their employ, and one representative consulting engineer with possibly a fourth from a railroad or public utility. This program should result in some very valuable material being brought out.

W. S. E. JOINS IN MID-WEST POWER CONFERENCE

The Midwest Power Conference is to be held in the rooms of the Furniture Club of America, 666 Lake Shore Drive, sometimes known as the Furniture Mart, January 26-29. The Western Society of Engineers is co-operating in arranging the program for this series of meetings which will be devoted to the Power Resources of the country, particularly of the Middle West. The program for this series of meetings is given below.

Members of the Society are invited to attend the sessions of this Conference. A registration fee of $1.00 will be charged for the purpose of defraying the incidental expenses of arranging this series of meetings. All those who register will be given a badge which admits them to all meetings of the conference, as well as to the Power Show which will be held in the same building at the same time. In addition there is a program of inspection trips which will also be covered by this registration. There will be no technical meeting of the Western Society that week, although plans are being made tentatively for a meeting under the auspices of the Junior Engineers devoted to the subject of Engineering Education. Members of the Society are asked to co-operate in making this series of meetings a success. The program is as follows:

Tuesday, January 26th

Registration from 10:00 A. M.
Opening Session — 2:30 P. M.

Chairman, W. L. Abbott, Chicago, President American Society of Mechanical Engineers.

Address, Samuel Insull, Chicago, "Some Comments on the Power Developments of the Mississippi Valley."

Wednesday, January 27th

Morning Session — 10:00 A. M.

Chairman, B. F. Lyons, Chicago, Ill., President Great Lakes Section, National Electric Light Association.

10:00 A. M. Daniel W. Mead, Madison, Wis., Consulting Engineer, "What We Can Expect from Hydraulic Power in the Middle West."

10:30. A. M. H. Birchard Taylor, Philadelphia, Vice-President The Wm. Cramp & Sons Ship and Engine Building Co., President Pelton Water Wheel Co. "Changing Viewpoints in Hydraulic Turbine Practice."

11:00 A. M. R. F. Schuchardt, Chicago, Electrical Engineer, Commonwealth Edison Co. "Super Power in the North Central States."

11:30 A. M. G. C. Neff, Madison, Wis., Chairman Rural Electric Service Committee, N. E. L. A. "Rural Electric Service."

Afternoon Session — 2:00 P. M.

Chairman, Homer E. Niesz, Chicago, President Western Society of Engineers.

2:00 P. M. William S. Monroe, Chicago, President Sargent & Lundy. "Recent Developments in Electric Power in the Chicago District."

2:30 P. M. C. F. Hirshfield, Detroit, Chief of Research Dept., Detroit Edison Co. "Present Practice in the Burning of Pulverized Fuel."

Wednesday Afternoon—Continued

3:00 P. M. H. W. Brooks, Fullerton, Pa., Cons. Engineer, Fuller Lehigh Co. "By-Product Processing of Coal."

3:30 P. M. Dr. R. E. Hall, Pittsburgh, Physical Chemist, Bureau of Mines Experiment Station. "Boiler Water Conditioning, With Special Reference to High Operating Pressure."

Thursday, January 28th

Morning Session — 10:00 A. M.

Chairman, James H. Herron, Cleveland, President the James H. Herron Co., Cons. Engineer.

10:00 A. M. Paul L. Battey, Chicago, President Battey & Kipp, Engineers. "Layout and Equipment of Industrial Power Plants."

10:30 A. M. G. B. Warren and J. H. Keenan, Schenectady, N. Y., Research Dept. General Electric Co. "A Machine for Testing Steam Turbine Nozzles by the Reaction Method."

11:00 A. M. C. B. Scott, President National Safety Council. "Safety and First Aid in Industrial Plants." Demonstration of First Aid by a Team from a Chicago Organization.

11:20 A. M. L. F. Harza, Chicago, Hydro-Electric and Hydraulic Engineer. "Planning and Operating Industrial Hydraulic Plants for Best Economy."

11:50 A. M. J. Paul Clayton Springfield, Ill., Vice-President Central Illinois Public Service Co. "Purchased Power for Coal Mines in Illinois."

Afternoon

Inspection Trips—Three main trips have been arranged, one to the Crawford Avenue Plant of the Commonwealth Edison Co., one to the printing plant of The Chicago Tribune and one to the Underwriters' Laboratory. Entree can be arranged to other plants of interest in the Chicago district for those who may so desire.

Evening — 7:00 P. M.

Dinner Meeting—The subject of the Dinner Meeting will be "The Effect of Wide Power Distribution and Availability on the Social and Economic Life of the Country and the Most Desirable Methods of Promoting and Controlling Such Development in the Hands of Private Enterprise."

Arrangements are under way to have these subjects treated by speakers of national reputation.

Friday, January 29th

Morning Session — 10:00 A. M.

Chairman, A. A. Potter, Lafayette, Ind., Dean of Engineering, Purdue University.

10:00 A. M. Max Rotter, St. Louis, Vice President and Engineer, Busch-Sulzer Bros. Diesel Engine Co. "The Diesel Engine in the Industries."

10:30 A. M. Samuel M. Vauclain, Philadelphia, President The Baldwin Locomotive Works. "The Diesel-Electric Locomotive, Its Present Status and Performance and Its Future Possibiliities."

11:00 A. M. Allen H. Brewer, New York, Consulting Engineer, The Texas Company. "The Economics of Oil as a Boiler Fuel."

11:30 A. M. H. H. Clark, Chicago, Industrial Gas Engineer, The Peoples Gas Light & Coke Co. "Present Status of By-Product Gas Furnace Practice."

Afternoon

Inspection Trips—Group inspection may be arranged for upon notifying the committee which has charge of this part of the program. Plants which visitors may wish to see are the Western Electric Plant at Hawthorne, the new plant of the International Harvester Company, Chicago Avenue Pumping Station, the Chicago Stock Yards, and it is possible that one of the large electric locomotives of the Chicago, Milwaukee & St. Paul Railway and the Diesel electric switching locomotive on test by the Chicago and North Western Railway may be available for inspection at this time.

Excursion to Automatic Electric Plant

January 22 is the date chosen for the next excursion which is to be to the plant of the Automatic Electric Co. at 1027 West Van Buren Street at 1:30 P. M. This visit can be made in any kind of weather and a large attendance is anticipated.

This plant is known as an example of the latest in manufacturing efficiency and it will be impossible to cover all of it in one afternoon. The party will be divided into groups with guides. Some will want to see the manufacturing departments while others will be more interested in assembly and testing operations. The guides will conduct groups through whatever departments they wish to see.

Uses of the Printing Telegraph

J. O. Carr, Engineer of the Morkrum Co. read a paper before the Society, December 7 on the "Uses of the Printing Telegraph." This is an instrument which was described in detail as to its operation and construction by Mr. Carr in a paper read before the society several years ago, so he did not attempt to go into the operation of the machine itself at this time.

Printing telegraphs are used for a number of purposes, other than for regular mesasge work on telegraph lines. Banks, brokers offices, hotels and large manufacturing establishments find use for printing telegraph equipment for the transmission of orders and memoranda between departments. Such use has made it necessary to develop a switching arrangement about on the same principle as the central office of the telephone system. The apparatus is mostly automatic and can be made to perform a number of combinations of services.

This paper went more into the commercial adaption of the equipment than into the technicalities of its construction. Mr. Carr illustrated his address with a number of lantern slides, showing applications of the equipment in various sorts of work and a number of different models that have been developed to meet a particular requirement.

Three Papers On Waterways Presented

The waterways of Illinois furnished the subject for a most interesting meeting December 14, at which there were three papers presented, covering the different phases of this subject, so important at the present time. L. D. Cornish, M. W. S. E., Asst. Chief Engineer, Division of Waterways and W. M. Smith, Designing Engineer presented a joint paper on the engineering and construction features of the Illinois Waterway. This paper was a technical description of the waterway which is designated to connect the Great Lakes with the Mississippi River. It described the engineering work done at every point between the upper end at Lockport and the junction with the Mississippi River at Grafton.

The second paper was by Murray Blanchard, M. W. S. E., Hydraulic Engineer of the Division of Waterways and dealt with the hydraulics and flood control problems encountered. Mr. Blanchard showed how the hydraulic features of the Illinois River have been changed from time to time, due to the construction of levees which restrict the channel and to the accumulation of silt. Particular attention was paid to the control of floods. In this connection it was pointed out, that the amount of water diverted from Lake Michigan has only a little effect on the height of water at flood times. Straightening and improving the channels of tributaries has resulted in bringing flood water from all of them into the main channel at the same time, thus aggravating the situation considerably. This paper contained a great deal of data on flood flows, rainfall, etc., and certain measures proposed for protection against floods.

The third paper of the evening was presented by W. G. Potter, M. W. S. E., Drainage Engineer of the Division of Waterways and covered the subject of improvement and utilization of the rivers of Illinois. Mr. Potter brought out the fact that practically all of our rivers have been ruined by being polluted with sewage, industrial waste, oil, ashes and other refuse matter. This condition is being gradually eliminated. This paper de-

scribed possible improvements in the minor rivers of the state, such as the Fox, Big Muddy, Pecatonica and others which are overshadowed by the amount of attention given to the Illinois deep waterway.

An interesting discussion developed at this meeting, which brought out the importance of giving thorough consideration to the economic features of the whole subject of water transportation and particularly the situation in Illinois. These papers with the subsequent discussions will form a valuable contribution on the part of the Western Society to the information available on the subject of Waterways in the State of Illinois.

"Standard Steel Construction Specifications"

Lee H. Miller, Chief Engineer, American Institute of Steel Construction, addressed the members of the Western Society, December 21, on the subject of "Standard Specifications for Steel Construction." This is in line with the efforts of the Institute to have uniform specifications for structural steel work adopted in all cities in the country where Building Code regulations are adopted.

Mr. Miller reviewed the history of the construction industry and the startling revolution through which it has gone since the introduction of structural steel which was first used in building the Tacoma Building in Chicago before the time of the World's Fair. The skyscrapers built in that time have completely changed the growth of American cities.

In the development of steel design there have been a number of disputed questions among which might be mentioned basic unit stresses and factor of safety. Mr. Miller presented a specification which has been drawn up with the hope that it will be adopted as a standard. It incorporates formulas that have been agreed upon by well known engineers and specifies unit stresses of 18,000 lb. per sq. in. Mr. Miller gave several examples of instances where this specification has been used and has resulted in a saving in the amount of steel required for structures, thereby greatly reducing the cost.

The American Institute of Steel Construction has just issued a handbook for distribution. This handbook contains a short history of steel and iron with an elementary discussion of the relation of external loads and internal stresses, in which is derived a number of fundamental formulas for use in designs. This is followed with a description of the tests on which these formulas are based and the standard specification for structural steel for buildings, and the code of standard practice. At the end of the book are a number of data sheets useful in the design of steel structures. Mr. Miller has sent a supply of these handbooks to the office of the Secretary, where they are available for distribution to any of the members of the Society who may ask for them.

There was a very interesting discussion of this subject following the address by Mr. Miller. Several of our members pointed out the necessity of taking proper precautions to insure competent design, rather than attempting to substitute new regulations. The burden of this discussion centered about the 18,000 lb. unit stress. It seemed the consensus of opinion that such stress is perfectly safe in the hands of a competent designer, but dangerous if not used with the proper amount of care in the calculations. The changes necessary in the Chicago Building Code to make it conform to the Standard Specifications recommended by the American Institute of Steel Construction were brought up for discussion. No action was taken.

Ralph Modjeski, Past President W. S. E. was elected an Honorary Member of the Engineers Club of Philadelphia at a meeting of the Board of Directors of that Club, October 20. A certificate of Honorary membership will be presented to Mr. Modjeski at a meeting at the Bellevue-Statford Hotel, Thursday, December 17, which is also the 48th Anniversary of the organization of the Club. Mr. Modjeski is Chief Engineer of the Delaware River Bridge Joint Commission, which is now building the large suspension bridge between Philadelphia and Camden, which is described in a paper by Mr. Modjeski given before the Western Society of Engineers two years ago.

Educating Engineers

Gerard Swope, President, General Electric Co. gave the members of the Western Society of Engineers and their guests, something to think about at the Noonday Luncheon held in the Auditorium Hotel, Tuesday, December 8, when he spoke on the subject, "Educating Engineers."

In calling the meeting to order, President Niesz pointed out that the Western Society of Engineers has furnished many men who have achieved national fame, the latest among whom is W. L. Abbott, Past President W. S. E. who has just been installed as President of the American Society of Mechanical Engineers. He introduced Mr. Abbott who responded to the hearty reception with a few words of thanks.

Mr. Swope has a very pleasing personality and told how his early goal when he first took up engineering work in Chicago in 1895 was a membership in the Western Society. He left Chicago, however, and became engrossed in his work elsewhere. His first enginering experience was in the shops of the Western Electric Manufacturing Company, Chicago. His first engineering experience was to calculate the size of a shaft required to mount a generator on an engine then in service. After much laborious calculation, he determined the size required and submitted his complete calculations to the engineer in charge who said, "Why didn't you take that out of a hand-book?" This taught Mr. Swope a lesson that he has never forgotten, namely, that it is well to know the fundamentals of engineering, but it is also important to use the experience of others who have gone before. Soon he began to think that the curricula of the engineering schools should be changed, but as the years past by, he became more convinced that there should be little if any change.

As his experience with engineers and educational institutions has increased, Mr. Swope has become convinced that there are four fundamentals which should be observed in engineering education, which might be summarized as follows:

(1) Better selection of candidates for engineering courses.
(2) Better training of engineering students.
(3) Greater opportunities for research and study on the part of both students and faculty.
(4) Greater interest on the part of Alumni.

In commenting upon these four fundamentals, he suggested that Alumni are not contributing their just share to the resources of the teaching staff of their Alma Mater and that the Western Society of Engineers might profitably have a committee operating in connection with the faculty of engineering schools, to bring the experiences of the members of the committee to bear on the curriculum so as to teach the applications of fundamental theories to actual practice.

Every one knows that there is an enormous waste or mortality among students, who think that they want to become engineers but after two or three years of study find that they are not fitted. A comparison of American Engineering colleges with those abroad, indicates that the average of the graduates of American schools is much superior to foreign universities, but that the leaders fall behind those in the upper fourth in other schools. This suggests that we should concentrate on the better men by selecting a special group and giving them added opportunities and responsibilities, while at the same time maintaining the high average of the regular course. Lack of funds and the routine of a heavy schedule makes it impossible for the instructors in our colleges to continue their research and study, so as to keep pace with the profession. Industrial laboratories are much better equipped for research and are taking the desirable men away from the colleges. Many of the larger industrial laboratories are now cooperating with colleges to make the results of their researches available to the students and faculty.

Mr. Swope said that in his judgment there was no limit to the opportunities of the present day and that he thought progress in research might be represented by a point traveling along the radius of a circle. Each new truth added to the sum of human knowledge opens up an increasing field of that knowledge which might be represented by the area

of the circle. This he said was a measure of the opportunities today. In this the engineers owe a definite obligation to coming generations as they have profited from the experiences of those who have gone before.

The attendance at this luncheon was such as to tax the facilities at the Auditorium Hotel and make it necessary to serve an overflow meeting in a room adjacent to the ball room.

Resolutions On National Defense and Topographic Mapping

Three important resolutions were passed by the Board of Direction at its December meeting. After study by the Public Affairs Committee and recommendation by that Committee, two resolutions regarding National Defense were approved. The first of these endorsing the National Defense Act and urging sufficient funds to maintain the regular army and national guard at their authorized strength is as follows:

"WHEREAS, The strength of the Regular Army should be 15,000 officers and 150,000 enlisted men, and of the National Guard 250,000 officers and enlisted men as authorized in the National Defense Act, and

"WHEREAS, The continued lack of appropriations sufficient to maintain the authorized strength of the Regular Army threatens its effectiveness in the training of the civilian components consisting of the Organized Reserve, the Reserve Officers Training Corps, and the Citizens Military Training Camps, now therefore,

"BE IT RESOLVED, By the Western Society of Engineers, Chicago, Illinois, that the Congress of the United States be urged to carry out the purport of the National Defense Act by appropriating sufficient funds to maintain the Regular Army and the National Guard at their contemplated and authorized strengths; and

"BE IT FURTHER RESOLVED, That copies of this resolution be sent to the President of the United States, the Secretary of War, Chairmen of the Senate and House Military Affairs Committee, and the Congressional Delegation from the State of Illinois."

Approved,
Board of Direction,
Dec. 21, 1925.
Edgar S. Nethercut, Secretary.

The second resolution is in reference to the Selective Service Law and is as follows:

"WHEREAS, The history of our country has shown that the voluntary system of raising troops in a National emergency is neither advisable nor effective; and

"WHEREAS, The Selective Service System, popularly known as the Draft System, used for the raising of troops in the late emergency was effective, and

"WHEREAS, It is of the greatest importance that proper legislation be enacted in order that selective service may be made operative immediately upon the declaration by Congress of a National Emergency; now therefore,

"BE IT RESOLVED, That we endorse the adoption of a Selective Service Law during the present session of Congress;

"BE IT FURTHER RESOLVED, That we endorse the Selective Service Law prepared by the Secretary of War, and that we urge the Congress of the United States to enact this draft or some other similar draft, which shall have the approval of the Secretary of War, into one of the laws of our country.

"BE IT FURTHER RESOLVED, That copies of these resolutions be sent to the President of the United States, the Secretary of War, Chairmen of the Senate and House Military Affairs Committees, and the Congressional delegation from the State of Illinois."

Approved,
Board of Direction,
Dec. 21, 1925.
Edgar S. Nethercut, Secretary.

Copies of both the above resolutions were sent to the President of the United States, Secretary of War, Chairmen of the Senate and House Military Affairs Committees and to the Congressional delegation from the State of Illinois.

The third resolution has to do with the topographic mapping of the United States as provided in the Temple Bill. It is understood that the Director of the Budget has recommended to the present Congress, that the appropriation for topographic mapping which is carried on in

conjunction with the various States be reduced considerably. This reduction would be a serious hindrance to the completion of the survey and the amount saved would be so small as to represent but little if any economy. The resolution expressing the opinion of the Society is as follows:

"WHEREAS, The Western Society of Engineers has previously expressed a favorable opinion as the advantages of an early completion of the topographic survey of the United States, and by resolution dated Sept. 20, 1925 endorsed the original Temple Bill, and

"WHEREAS, The Society has endeavored to secure the adoption of this plan during the succeeding sessions of Congress, and

"WHEREAS, The Society believes that the provisions of the Temple Bill as passed represent the concurrence of judgment of the Engineering profession as represented by the action of various societies, both local and national, and as presented before the committees of Congress, and

"WHEREAS, The recommendation of the Director of the Budget to the present Congress is such as to practically nullify the judgment of the Engineering profession and postpone completion of this important work, and

"WHEREAS, The recommendation of the Director of the Budget provides a much larger proportional reduction in the funds for topographic surveys compared to the provisions of the Temple Bill and the recommendation of the Director of the Geological Survey than other recomendations for appropriations.

"BE IT RESOLVED, That the opinion of the Western Society of Engineers be and is, that economy as represented by the recommendation of the Director of the Budget is not true economy and,

"BE IT RESOLVED, That the society urge congress to make an appropriation for the next fiscal year at least equal to the provisions of the Temple Bill."

Approved,
Board of Direction,
Dec. 21, 1925.
Edgar S. Nethercut, Secretary.

Jerome A. Moss, M. W. S. E. has moved his office from 608 S. Dearborn St. to Room 532, 80 E. Jackson Blvd.

H. C. Gardner, M. W. S. E., President of the Great Lakes Tide Water Association spoke to the members of the Cleveland Engineering Society at their meeting in Cleveland, November 10 on the subject, "The Economics of the Proposed Great Lakes Ocean Waterways." In making plans for this meeting, the Cleveland Engineering Society decided that on account of the wide interest in the subject and the speaker, it would be necessary to limit attendance to members of that Society, or those who obtained guest cards from the Society's office. The Secretary reports that this plan has been tried on various occasions and always meets with particular success. The fact that it is necessary for a member to produce his membership card to obtain admission to the meeting tends to place a higher value on membership in the Society and to stimulate interest in that particular meeting.

Although the average attendance at meetings of the Cleveland Engineering Society is about seventy, there were two hundred fifty who attended the meeting at which Mr. Gardner spoke.

It sometimes appears as though it would be a good thing for the Western Society of Engineers to do once in a while, to restrict attendance at its meetings to its own members. The subject is worthy of some consideration. We wonder how the members feel about it.

The John Fritz Medal Board of Award has issued a sixty-four page book, giving a history of the John Fritz Gold Medal which was this year awarded to John Frank Stevens in recognition of his achievements as a Civil Engineer. This medal is awarded annually by a Board of representatives from the Four Founder Societies. Presentation of the medal occurred Monday, March 23, 1925.

The book contains a biography of the recipient of the Award, together with the addresses made at the presentation meeting and a history of the accomplishments upon which the Award was based. If any of the members of the Society are interested in receiving a copy of this booklet, the Secretary has a few for distribution to any who care to call at the office for them.

Are We Courteous?

Sometimes it seems as though it might be necessary to give some of the members and guests of the Western Society, a few lessons in courtesy when attending our meetings. Engineers as a class are supposed to be educated and at least to know how to behave themselves with proper consideration for others who are attending a meeting and trying to learn something from it. These remarks are prompted by the frequent observation of the amount of disturbance created during meetings. It frequently happens that as soon as a speaker has finished with his prepared paper, there will be a grand rush for the door, resulting in so much confusion that nothing can be heard for several minutes. There are always those who get up and go out during the middle of a meeting to catch an early train. Our meetings are started an hour earlier than any others that we know of, just so that they may be adjourned early. It is seldom that a meeting lasts later than 9:30, but how many of those who persist in breaking into one of our meetings, in order to catch that early train, would think of doing the same thing at a theatre, which is seldom closed before 11?

Another thing that is very annoying is the matter of talking in the back of the room, while a speaker is delivering a paper. At a recent meeting, two well known members of the Society sat in the back of the room and visited throughout the meeting, carrying on a conversation in an undertone, which was disturbing nearly everybody in the rear half of the room, as was evident by the number who turned around to see what was going on.

A little consideration for others in a matter of this kind is desirable. Courtesy to a speaker and to those in the meeting is a mark of good breeding.

T L. D. Hadwen, M. W. S. E., who has recently returned from a trip through Europe has now started on a trip around the world. While in Sweden Mr. Hadwen had an interesting visit with Baron G. A. M. Liljencrantz, M. W. S. E., who is well known to a number of our older members, because of his activities in the Society, while residing in Chicago.

A Word About the Junior Engineers

One of the most encouraging things about the whole program of the Society is the interest being shown by a small group of the Junior Engineers. It will be recalled that this was formerly called the Young Men's Forum and as a separate organization held its meetings independent of the technical programs, generally on Wednesday. The program was entirely different from that of the Society.

This year the Forum was reorganized as the Junior Engineers of the Western Society and instead of attempting to set up an entirely different program, the Juniors have arranged their meetings along the same line as the main technical program of the Society. The Junior Engineers meet at 6:30 P. M. every Monday evening in the Conference Room. Frequently they arrange to have the speaker of the evening be with them and take up an informal discussion of the subjects to be presented at the meeting which is to follow.

These meetings are very informal as the men sit around the table and ask questions on anything that may occur to them. The result is a wholesome discussion which is very informative. The men who come are the ones who get the real good out of it. For example, a few weeks ago when Prof. Mylrea presented his paper at the evening meeting, he met with the Junior Engineers and talked to them about the problems met in designing reinforced concrete structures. There was one of the members who had a question that had been bothering him for some time on a structure that he was designing. He brought up the subject for consideration and the discussion that followed cleared up the problem immediately. He said that, that was just one instance of the benefit that he got out of those meetings.

The Junior Engineers would like to have every young man feel that he is welcome to come into these meetings, get acquainted and have the benefit of a half hour of discussion among a group where he need not be afraid to ask questions that he might hesitate to bring up at the larger meeting.

It wouldn't do some of the older members any harm if they would come into

these meetings once in a while, to find out what the young men are doing. It is here that they will find the men who are some day going to be the real engineers of this community. If the interest that they have shown in the work this far is any indication, it is very certain that there are some good leaders to be picked out of the group.

Wind Pressure On Model of Building Determined By Bureau of Standards

The average wind pressure on a tall building when the wind is blowing at 76 miles per hour (100 miles per hour, as shown by Weather Bureau, Robinson type anemometer) is about 22 pounds per square foot, according to results obtained by the Bureau of Standards, Department of Commerce. The value which is commonly used is 30 pounds per square foot. This would correspond to a true wind speed of about 88.5 miles per hour (118 miles per hour indicated speed). Gusts of this speed have only been observed in a few cities, such as New York, and St. Paul.

The results were obtained by measuring the force of the wind on a model of a tall building mounted in the large outdoor wind tunnel of the Bureau. This tunnel is 10 feet in diameter, and in these experiments winds up to 70 miles per hour were produced, values for higher speeds being obtained by extra polation. By means of small openings in the face and top of the model which were connected to a pressure gauge, the pressures produced by the wind at various parts of the structure were measured. These measurements were made at 70 places on the face of the model and at 49 places on the top, with the wind coming from 13 directions, varying from directly against one face to directly against the opposite face. Of course, in this work the wind always comes from one direction, and the model is turned on its mounting. The pressures obtained were then multiplied by the appropriate areas to give the total force on the model under the different conditions. The forces tending to overturn and to twist the model were also computed.

This work was undertaken because of the many inquiries received by the Bureau concerning wind pressures on buildings. The same experimental methods were employed which have been found so useful in the investigation of air forces on airplanes.

It has always been recognized that in the design of engineering structures such as tall buildings, bridges, chimneys, transmission lines, radio masts, etc., it is necessary to make provision for the stresses produced by the pressure of high winds. However, the values of the forces produced by the wind used by engineers in structural design are based on experiments made a great many years ago by methods which are now known to be subject to large errors, and on models which do not resemble actual structures. Many engineers have felt that these old values are too large, and that many structures are made stronger than is necessary, and therefore cost more than they should.

The Bureau has determined the actual pressure corresponding to a given wind velocity. There still remains the problem of determining what wind velocity to use in designing a structure. Obviously, a higher velocity ought to be assumed in designing a building facing the lake front in Chicago than for a building in the downtown section of Washington.

Would You Have Done This?

(A True Story)

He was the average type of fairly successful engineer, who had raised a family, and who did all the ordinary things in life without attracting either highly favorable or unfavorable comment from his neighbors and friends. He had a nice home and family, revelled in his garden, and took pride in his children—really the highest type of American Citizen, the kind you picture in your mind's eye when looking at Herbert Johnson's cartoons in the Saturday Evening Post, showing the "Public" in its relation to all our present day economic evils and glories.

Opportunity knocked. Our Mr. Average Man was told that he was the one logical contender for the place of chief responsibility in a large manufacturing concern to be organized. Imagine his feelings. What a pride he would be to

his family. What a justification of the life that he had led. What a happy man was made by the committee's selection of him to be their head.

Mr. A. Man took an immediate interest in the project, an interest based on his long familiarity with the processes employed, and not indirectly connected with the knowledge that HE soon would be directing its fortunes. The first way he expressed his interest was by coming to the Library of the Western Society of Engineers to learn all he could of the recent developments in his proposed field. With the assistance of the Librarian he secured all the literature that had been published on that particular subject.

What he found enabled him to persuade his colleagues to abandon some of the details of their plan which eventually saved them from tremendous litigation and annoyance. While he thereby delayed his own advantages, he increased his opportunities, gained the good-will and confidence of his colleagues and preserved the good repute of both the organization and himself.

This is a true story of an incident that happened within the last few months. The man was not a member of the Society at the time, but he immediately realized the benefits of membership, and sent in his application.

Jacob Sonderegger, Junior member of the Western Society of Engineers has returned to Switzerland, after ten months in America. Mr. Sonderegger, a native of Switzerland, was desirous of settling in America. He found, however, that the immigration quota from Switzerland was filled and he could not enter the country with the intention of settling. His next best opportunity was to come as a visitor, with a stay limited to six months. This was subsequently extended to ten months and at the end of the period he was required to return to his native country. He will re-enter the employ of Siemens & Halske at Zurich, with which company he was employed before coming to America.

Mr. Sonderegger before leaving expressed his very high appreciation of the benefits of membership in the Western Society of Engineers. He has been a very faithful attendant at the technical meetings, the entertainments, and excursions and has been an earnest student, of the resources of our Library. While in America he has been employed with Sargent & Lundy and with the Automatic Telephone Company as an Electrical Engineer.

Edward J. Fucik, M. W. S. E., Vice President and Director of the Great Lakes Dredge & Dock Co. has resigned to accept a similar position with the Fitz Simons & Connell Dredge & Dock Co. Chicago. Since his graduation from the University of Illinois in 1901, he has been connected in various capacities with a great deal of the construction work on the Chicago River, the Sanitary District's Canal and various harbor and dredging projects on the Great Lakes. He has had charge of construction of dams, docks, dry-docks, etc., involving many different kinds of construction.

Employment Service Has Openings

The Engineering Societies Employment Service, Chicago Office, has been in operation for over four months. It is supplying a real need and rendering a service, which is not only helpful to the engineering profession but also to the industries, depending upon engineering talent. From the standpoint of employment, the activities of the Chicago Office indicate that there are large calls for engineers, compared with the number of men who have made application for positions.

It frequently happens that there are men available and positions open, but the qualifications of the men do not match with the requirements of the position. At the same time it is altogether likely that there are men whose qualifications would match, but unless the application is on file at this office, we are not able to take steps to fill the position. It would be very helpful both to employers and employees, if any of our members who contemplate making a change would register promptly. Members who register may subscribe to the bulletin, containing a list of positions open. The

subscription price is $3.00 for three months and the bulletin is published weekly. The bulletin contains a list of positions open as registered in the New York Office and in the Chicago Office. It will contain positions registered in the San Francisco Office which has only recently been open.

An analysis of a recent bulletin indicates the following positions open:

Junior engineers and recent graduates, civil 3, electrical 5, mechanical 5, mining 1.

Draftsman, civil 8, electrical 1, mechanical 6.

Positions requiring engineering experience, civil 9, electrical 5, mechanical 19, mining 1, general 3.

Positions over $5,000.00, civil 4, mechanical 4, general 1.

There are also positions open for instructors, salesmen, miscellaneous designers, covering various degrees of experience.

This would indicate that there are positions open. The specifications, however, for these positions may not match with the experience of members who are registered. Enginers who are looking for a change of position, will undoubtedly find during the three months period of subscription, some positions which would interest them.

The Employment Service also publishes a bulletin listing engineers and executives available. Members who register with the Employment Service may have their qualifications published in this bulletin. It is especially useful, however, to employers of engineers and anyone can subscribe to this bulletin, which is issued weekly, at $10.00 per year. It is a plan of the service to make it as nearly self sustaining as possible and while no fee is charged, members of the Society who are placed in positions are requested to contribute an amount based upon the salary, as a voluntary fee. This fee amounts to about one-fifth of the ordinary fee charged by employment gaencies. It is a special service in the interest of certain members of the Society and should if possible be self sustaining. For full particulars apply to Mr. A. Krauser, Manager, Room 1736, Monadnock Block.

Attention of employers is directed to the following list of members of the Society who are available for employment and are registered with the Engineering Societies Joint Employment Service,

141—**Tool designer:** Age 34, tech, education. 5 yrs' experience on designing, machine operation, and inspection. Prefer Chicago location with local manufacturer.

214—**Chief Engineer for contractor or railroad:** Age 43, tech, education, married. Broad experience in all phases of construction work. Prefer middlewest or Pacific Coast.

256—**Mechanical Engineer:** Age 34, tech. education, experience in heating and ventilating. Desires position with architect.

277—**Const. Supt. or designer:** Age 25, C. E. grad. Univ. of Ill. Experience covers detailing and designing structural and reinforced concrete power plants and mill buildings. Desires position with contractor or architect.

289—**Chief draftsman:** Age 24, tech. education in M. E. now employed as ass't. chief draftsman, desires position as chief draftsman with small manufacturer.

291—**Machine designer:** Age 39, single, tech. education, eight yrs' experience in detailing and designing, desires permanent position in Chicago.

292—**Mechanical detailer:** Age 27, married, experienced on blast furnaces, coke ovens, and structural steel. Desires local position.

304—**Surveyor:** Age 29, C. E. graduate, single. desires position as surveyor or structural detailer, 3 yrs' experience. Will go anywhere. Reasonable salary.

311—**Sales manager or representative:** Age 44, grad. E. E. Broad experience as sales engineer. Will consider position as local representative or branch manager. Chicago territory.

324—**Bldg. inspector and surveyor:** Age 30, C E. graduate, experienced in estimating and building construction work, also instrument man. Desires position in Chicago.

329—**Estimator:** Age 22, C. E. education. Desires position in sales or estimating on heating or construction work.

332—**Industrial Engineer:** Age 41, M. E. graduate, maried, experience covers production and maintenance work. Desires executive position.

340—**Concrete and structural designer:** Age 37, Graduate C. E., married, experienced on industrial and railroad bldg. construction, also estimating and bridge designing.

342—**Sales engineer:** Age 36, married, tech. education in M. E. manufacturing experience, desires local position in sales work.

345—**Industrial gas and chem. Eng.:** Age 23, graduate in Ch. E., single, one yr's experience industrial gas engineering desires position as sales engineer or ass't. engineer.

350—**Mechanical draftsman:** Age 27, tech. education in M. E., married, eight yrs' experience. Desires work on gas or steam engines, hoisting or conveying machinery.

352—**Civil engineer:** Age 25, graduate. Experience covers detailing reinforced concrete and ass't engineer on construction work. Desires position as construction engineer, sales engineer, or city planner.

356—**Foreign representative:** Age 36, married. C. E. graduate. Speaks Spanish fluently. Experienced construction and designing engineer. Desires position as sales engineer or foreign representative.

361—**Executive and sales engineer:** Age 37, M. E. education, married, broad experience in factory management, also production purchasing, and sales. Desires executive position in manufacturing or sales work.

APPLICATIONS FOR MEMBERSHIP

Members of the Society can be of great service if they will make a practice of examining the list of applicants published herewith and promptly notifying the Membership Committee or the Secretary regarding the qualifications of any of those whose names appear on the list. The Society desires to extend its membership and receive those engineers who have the proper qualifications and wish to participate in its activities. The following applications have been received since last report:

No.	Name	Address
237	Horatio B. Hackett	Room 1400 Monroe Bldg., Chicago, Ill.
238	Fred L. Hicks	Box 286, Frankfort, Ky.
239	Joe L. Smith	2859 Leland Ave., Chicago, Ill.
240	Irving N. Kilstofte	Room 840, 72 W. Adams St., Chicago.
241	C. R. Hoyt	South Park Commissioners, Chicago.
242	Nicklass Rozema	% Roy Leas, C. R. I. & P. R. R., Billings, Okla.
243	F. H. Doddridge	537 S. Dearborn St., Chicago.
244	James K. Duncan	Harper Hotel. 5701 Harper Ave., Chicago.
245	Benj. Myllymaki	3800 S. Michigan Ave., Chicago.
246	John A. Moline (Trans.)	438 S. Clinton St., Chicago.
247	Millard I. Thompson	529 Bryant Ave., Glen Ellyn, Ill.
248	Henry A. Anfinson	2709 Prairie Ave., Chicago, Ill.
249	Herbert F. Carter	1639 S. 50th Ave., Cicero, Ill.
250	Jos. H. Chubb	210 S. La Salle St., Chicago, Ill.
251	C. D. Hart	240 S. 5th Ave., La Grange, Ill.
252	Hugh Fulton	547 W. Jackson Blvd.
253	Henry M. Zukowski	4624 S. Winchester St., Chicago.
254	W. S. Steiner	5014 Blackstone Ave., Chicago, Ill.
255	James D. Green	3133 Princeton Ave., Chicago, Ill.
256	Anthony F. Algiers	5109 Medill Ave., Chicago, Ill.
257	Arthur S. Grossberg	6802 Clyde Ave., Chicago, Ill.
258	Angelo M. Rajani	3835 W. Van Buren St., Chicago, Ill.
259	George D. Estes	213 N. Taylor Ave., Oak Park, Ill.
260	Alexander Haritonoff	3645 5th Ave., Chicago, Ill.
261	W. H. Fenley	709 Peoples Gas Bldg., Chicago.

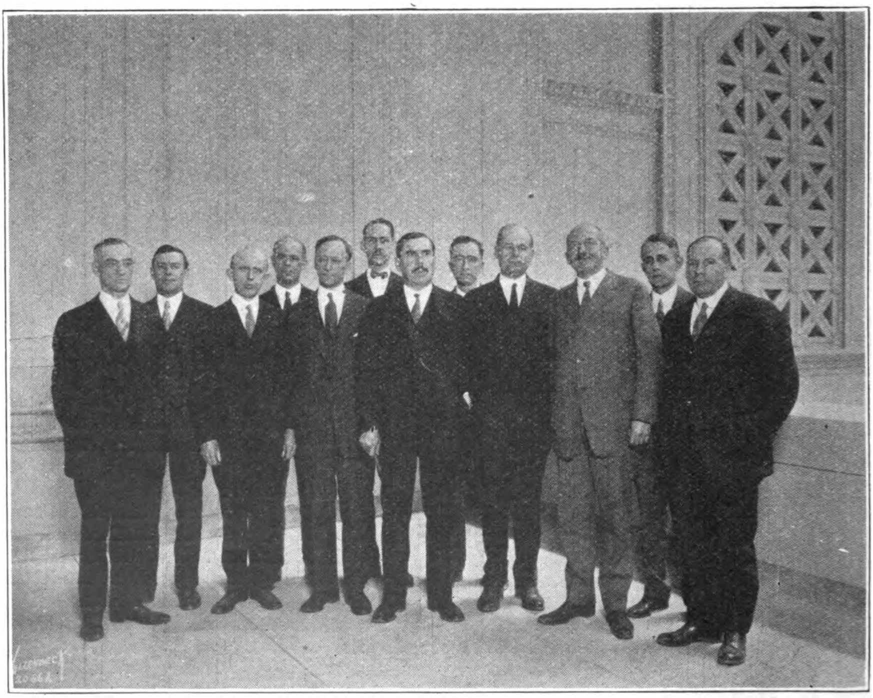
NEW MEMBERS

The following were elected to membership in the grade shown by the Board of Direction at its meeting, November 19, 1925:

No.	Name	Address	Grade
143	Richard B. Campbell, (Transfer)	426 Arlington Pl., Chicago	Associate
161	Samuel Friedman (Trans.)	362 E. 26th St., Chicago	Affiliated
177	Philip H. Eichler, Jr. (Transfer)	31 McArthur Pl., Middle Village, L. I.	Junior
179	Lawrence L. Flint (Trans.)	Box 104, Sanborn, Iowa	Associate
182	Alvin W. Cockrell (Trans.)	5117 W. 27th St., Cicero, Ill.	Junior
185	C. F. McCandless (Trans.)	Ludington, Mich.	Junior
192	Theodore Kimball	308 S. Superior St., Angola, Ind.	Student
193	Martin Nelson	Y. M. C. A., Gary, Ind	Affiliated
194	Wilbur G. Thompson	Cazenovia, N. Y.	Student
195	Floyd C. Double	Cortland, Ohio	Student
209	Edwin Zeleny	373 Forest Ave., Glen Ellyn, Ill.	Member
210	Howard D. Harvey	553 S. Locust St., Valparaiso, Ind.	Member
211	Ralph J. Dodds	3219 S. Michigan Ave., Chicago	Student
212	Herbert O. Kukral	3219 S. Michigan Ave., Chicago	Student
213	Edward J. Hauer	4917 Blackstone Ave., Chicago	Junior
214	Samuel K. Brown	3210 Arthington, Chicago	Associate
215	Harold J. McKeever	7255 Evans Ave., Chicago	Associate
216	Harold E. Wessman	5808 South Park Ave., Chicago	Associate
217	Robert M. Stull	2514 Prairie Ave., Chicago	Student

NEW MEMBERS—Continued

218	John W. Rowley	1243 Railway Exchange Bldg.	Associate
219	Robert P. Petersen	4118 N. Parkside Ave., Chicago	Student
220	Robert F. Lyons	118 E. 26th St., Chicago	Student
221	Meyer Louis	1855 S. Troy St., Chicago	Student
223	Louis N. Hitchcock	7412 Vincennes Ave., Chicago	Member
224	William T. Blunt	70 Cuna St., St. Augustine, Fla.	Member
226	Scott R. Conwell	456 Deming Pl., Chicago, Ill.	Student
227	John F. Rithmiller	456 Deming Pl., Chicago, Ill.	Student
228	L. B. Kordell	2639 Armitage Ave., Chicago, Ill.	Junior
230	H. B. Palm	2140 Burling St., Chicago, Ill.	Student
231	Donald J. Braden	6237 Ingleside Ave., Chicago	Student
232	C. G. R. Johnson (Trans.)	Norman, Okla.	Junior
233	Otto Brouk	118 E. 26th St., Chicago	Student
234	John W. Webster	113 Jersey Ave., Joliet, Ill.	Member
235	Raymond S. Knapp, (Transfer)	11066 S. Irving Ave., Chicago	Member
236	Charles M. Davison	6 S. Grant St., Hinsdale	Associate



This issue of the Journal concludes the notable series of papers on the Chicago Union Station. The authors of those papers modestly gave the credit to others for the success of the work described by them. The accompanying photograph shows a group of the men to whom the credit should be given. They are the engineers actually in charge of building the station and the authors of all these papers are in this group.

TECHNICAL PAPERS

JOURNAL OF THE
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Bearings for Horizontal General-Purpose Motors

By HOWARD MAXWELL*

Presented Nov. 10, 1924

We present herewith abstracts of three papers covering the principal types of bearings and their application in industrial uses. It is impossible to present all of the illustrations which were used at that meeting but the text describes the types so that their explanation is clear. These papers present the result of years of experience and investigation on the part of different manufacturers and may be said to fairly represent the opinions of those who are best qualified to discuss the respective subjects. —Editor.

DURING the past twenty years the motor designers have endeavored to substitute ball or roller bearings for sleeve bearings for certain kinds of service and in certain types of machines. It is safe to say that the extent of their progress in this direction has been in direct proportion to the success attending their efforts in the use of these types of bearings. The most ardent proponents of ball and roller bearings have been impatient at times over what seemed to be the slow progress made in introducing these bearings into general motor use, but I think that even they would agree with me that if ball and roller bearings had been applied to all motors 15 or 20 years ago with the limited knowledge and experience available at that time, that the results would have been very detrimental to the ball and roller bearing interests as well as to the motor industry.

There is today a growing demand for general purpose industrial motors equipped with ball or roller bearings. Many motor manufacturers who have not regularly supplied them heretofore are weighing the need of meeting this demand in their standard lines, so that it is well to consider at this time the progress that has been made in the use of ball and roller bearings.

The greatest assurance of success in the introduction of ball or roller bearings into standard lines of motors at this time lies in the fact that the designers of these bearings now agree on many details on which there was in the past a wide diversity of opinion. Among these details may be mentioned:

Lubrication

It is now agreed on general purpose motors operating below 2000 r. p. m. that a light grease is to be preferred. It forms a better seal against the intrusion of grit. As it is less likely than oil to escape from the housing, it should require less frequent replacement of the lubricant and consequently less attention. One of the principal advantages so far developed for ball or roller bearings over sleeve bearings as heretofore made is in their claimed freedom from oil or grease leak-

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age which finds its way on to the windings of the motor, and causes insulation trouble. In order to make good on this claim where grease is used, it will be necessary to educate the motor users not to overfill the bearings as there is no way to limit the quantity of grease inserted as can be done with oil lubrication where overflow gauges are used to determine the oil level.

Standardizaticn of Sizes

The principal makers of ball bearings during the past year have agreed to a list of sizes of bearings to be used with the different motor ratings. This list combining as it does the knowledge and experience of the many ball bearing engineers into a single recommendation, is of the greatest assistance to motor designers and gives assurance to all, that now we are better prepared to extend the use of ball and roller bearings than we have been heretofore.

This standardization of sizes is of the greatest importance to motor users in that it simplifies the problem of renewal bearings. Most of the ball bearings and some of the roller bearings are now interchangeable with each other, and if motor makers use the same size bearings, or at least the same series of bearings, it becomes very easy to provide for supply parts. For this act of standardization we are indebted to the suggestion and help given by the steel mill engineers.

Assembly

It is commonly accepted that the inner race should be assembled on the shaft under a very light pressure fit such as would be secured where the shaft about half a thousandth, or less, larger than the inside diameter of the inner race. This will prevent it from rolling on the shaft as it alternates from loaded to unloaded side. In addition it is generally recommended further to secure the inner race between a clamping nut and a shoulder on the shaft.

The success or failure of ball bearings is closely allied to the manufacturing tolerances and assembly fits. If an inch cube of steel be compressed so that its length be shortened one ten thousandth of an inch, it is being loaded 2800 lb. With this fact in mind one can picture the effect of any slight inaccuracies which tend to cramp the balls and see that such unnatural loads may very easily exceed the normal capacity of the balls. I am quite confident that ball and roller bearings makers understand and are able to meet the tolerances required. An evidence of their appreciation of the practical side of this is that they now make the ball or roller clearance between raceways a little more free so that we can press the inner race on a shaft where it is a little bit over normal allowance without cramping the balls.

Enclosure

In the details of the enclosing covers at the ends of the bearing housing there may yet be some slight difference in methods of grooving recommended, but even here they all follow along the same general lines.

Ball or roller bearing equipped motors now designed according to the above standardized practice and using the recommended sizes of bearings which are one to three sizes larger than those commonly used before should give satisfactory service. It is no longer a question as to whether ball and roller bearings will or will not work satisfactorily in motors, but rather whether or not the ball and roller bearings offer advantages over sleeve bearings which warrant their general use in the face of greater initial cost of the motor. I will confess that I do not know a simple answer to this question, and I think it will require much more extensive use of ball or roller bearings in general purpose motors than now exists to establish the comparative value of the various claims of superiority. There are several points of comparison which are commonly made which can be intelligently discussed in the light of present experience.

Saving In Friction Loss

I mention this first because it was one of the first claims made for ball and roller bearings. In fact, today these bearings are commonly known and designated as anti-friction bearings. This idea originated perhaps because their static or

starting friction is so low that it was quite natural to assume that they would have little or no friction under full speed. It was a great disappointment to motor designers to find out many years ago when they first equipped their motors with ball and roller bearings that these bearings had about the same friction loss as the oil-ring sleeve bearing. We made very careful tests then, both at no load and with the bearings carrying the load of a heavy fly wheel. In making the load tests the motor with sleeve bearings and fly wheel assembled on the shaft was allowed to coast from full to zero speed without power supply, and a deceleration curve plotted between time and speed. A similar deceleration curve was also taken with the same motor and fly wheel but using roller bearings.

It was found after repeated check tests that from 1800 r. p. m. down to 600 r. p. m. it required 20 minutes with either type of bearing, but from 600 to zero speed the sleeve bearing stopped in 26 minutes and the roller bearing motor stopped in 38 minutes.

There was practically no difference in the friction. Both machines stopped in about the same length of time. Below that the roller bearing had less friction by about 30 or 33%.

Many later tests made at no load on both ball and roller bearing motors indicate that there is no appreciable difference in the friction loss of either type in motors operating at moderate or high speeds. We have taken the trouble to check motors of other than our own make equipped both with ball and sleeve bearings, and find that they likewise show no difference in running friction loss.

Over-All Length of Motor

When ball bearings were first used many years ago, it was quite common to recommend much smaller sizes, and also lighter series of bearings than is customary today, so that the impression was formed at that time that they afforded a means of shortening up the over-all length of motor because being small in diameter they could be extended further inside the motor.

With the larger bearings now standardized and commonly used, the outside diameter of the bearing housing is too large to extend inside the rotor windings. It has been our experience that the length over the bearing housings cannot be made less on the ball and roller bearing motors, at least in the sizes up to 50 hp.

Smaller Air Gaps

It has been proposed to reduce the radial clearance or so-called air gap between the rotating and stationary members of a motor where ball or roller bearings are used, and therewith rearrange the design to reduce the cost or improve the motor characteristics and thereby profit by this reduction. The air gaps now commonly used in induction type of motors are now quite small and are generally thought to be the minimum required by considerations other than bearing wear or clearance. They vary from about 10 or 12 mils on a 1 hp. motor up to about 30 to 35 mils on a motor of 50 hp. capacity.

I have yet to find a designer who had courage to make the clearance much smaller with any kind of bearings. On direct-current and synchronous motors the air gap clearances are much larger, but they are set by electrical requirements and would not be made smaller with other types of bearings.

Maintainence Costs

When we take up the subject of maintainence costs we will find data presented and opinions expressed by those using motors in certain classes of service which prove a very considerable advantage on the side of ball and roller bearings over sleeve bearings. This advantage appears in motors used in foundries, steel mills, cement mills and other locations where the air is laden with gritty dust. I believe that this kind of service offers the most promising field for the immediate extension in the use of ball or roller bearing general purpose motors.

It is not argued that ball and roller bearings suffer less from the effects of grit in the lubricant but rather that the form of enclosure and the use of grease

instead of oil prevent the entrance of grit into their housings. The designers of ball and roller bearings have thus indicated to the designers of sleeve bearings the need of more attention to dirt seals and in the past several years this detail has received more intelligent consideration so that the modern sleeve bearing motor is much improved over its predecessors in this respect. It is often contended that the present comparison of bearing life in dirty places is based on old designs of sleeve bearing motors but it still remains for sleeve bearing designers to prove that their bearings are or can be made equal to ball and roller bearings in this respect.

Where the bearings fail and have to be replaced every few months as has been reported occasionally the maintainence cost runs into very large figures each year, and it then overshadows all other considerations. In plants suffering acutely from such trouble I do not expect those responsible for maintainence to give much weight to other points favoring sleeve bearings. However the number of motors located in such extreme conditions of grit-laden air are few as compared with the many in comparatively clean air and thus the importance of this advantage becomes less when considered for a complete line of general-purpose motors.

Oil Leakage

The escape of the lubricant from the bearing enclosure of sleeve bearing motors also is largely a question of the design, and manufacture of the housings.

A certain amount of this kind of trouble is due to careless filling of oil wells. The oilers frequently spill oil over the outside of the motor and many of them too often add oil when the motor is running. It seems possible that more trouble may arise due to too frequent oiling of motors than due to lack of attention causing the oil wells to run dry. So much has been said along this line recently that I have been watching a 15-hp. motor which runs continuously and which has been operating now for nine months without addition to or change of oil. Judging from the amount of oil that has evaporated or escaped in any way I would expect the motor to run another year without adding oil. This motor is not special in any way, it is equipped with the present standard design of sleeve bearing.

I think that as soon as we collect more data, the designers of plain bearings should start a campaign against over-lubrication. It is not safe to do this today because I do not believe we know how long the bearings can operate without renewal or replacement of the oil well enough to advise our customer on this point.

I think too much insulation trouble has been charged to the effect of oil on windings. While oil does tend to soften some kinds of insulating varnish and may in certain bad cases be the prime cause of insulation failure still I do not think it is as serious generally as some people have been led to believe.

Whether or not ball and roller bearings have and can maintain a just claim to advantage over sleeve bearings in this respect hinges on whether the attendants over fill them with grease. When grease is inserted through a plug or pressure fitting there is no indication that the proper amount of grease has been applied until it appears at the openings around the shaft. It is our observation that ball bearings are also generally over-lubricated. Grease is surely as detrimental as oil to the insulation of all coils.

Life of Bearings

It would require a great deal more data than I have available and in fact than I believe is available any where intelligently to compare the life of sleeve with ball or roller bearings used in motors. We know of a few ball and roller bearings motors that were built 10 to 15 years ago and are still running satisfactorily. We also know of some of the first induction motors sent to one of the southern textile mills more than thirty years ago which have run continuously every day and also much of the time at night at constant overload of 25% and in which a recent investiga-

tion showed that 6 motors out of the 14 were running on their original sleeve bearings.

All this is interesting but it does not add much useful knowledge on the life of bearings. We need to know what percentage of bearings, ball, roller or sleeve fail the first year, what percentage the second year and so on but such data are not available for motor applications.

I have mentioned the life of bearings in order to bring out a point which has often occurred to me when considering ball and roller bearings. The journal of a sleeve bearing runs on a film of oil which separates it from the bearing surface, and under ideal conditions there can be no wear or deterioration in the bearing or journal and under such conditions its life is therefore infinite. In a ball or roller bearing the parts are in metal contact and are subject to rapidly repeated stresses which deform the surface and bring into operation the laws of fatigue of metals. These laws teach us that metals subject to repeated stresses eventually break down after a given number of repetitions of the stress, depending upon magnitude of the maximum stress. Therefore ball and roller type of bearings do have a certain definite useful life.

This is not an argument against the use of ball or roller bearings in itself, but simply emphasizes the necessity of selecting ball or roller bearings large enough to avoid the overstressing of the parts.

I was very much pleased to find reference to this in a paper by Mr. Brunner printed in the May issue of the Iron and Steel Engineer, and to realize that the ball bearing engineers had investigated the life of bearings on the basis of fatigue, I believe we can therefore trust that their present day recommendation as to sizes is on a very conservative basis of load rating.

Vibration and Noise

Vibration is more readily carried through a shaft supported on ball bearings than one cushioned on an oil film in a sleeve bearing. This is especially true for such periodicity of vibration as may be encountered with spur gearing and some of the worst cases we have encountered have been severe enough to crystallize the rotor windings. The noise made by the motor also is more noticeable with ball than with sleeve bearings. However, these points can generally be satisfactorily overcome if given proper consideration by the motor designer.

Cost

The difference between a standard horizontal general-purpose motor equipped with ball or roller bearings, and one equipped with oil-ring sleeve bearings, will vary some what with different companies, depending upon the development of their equipment and methods of making sleeve bearings. When expressed as a percentage it will vary considerably with the size and type of motors compared, but I can say with fair degree of accuracy that on the squirrel cage, or most popular type of motor used today, in sizes up to 50-hp. the cost will be increased at least 10% by substitution of ball or roller for sleeve bearings.

We cannot help but admire the ball and roller bearings made today as wonderful mechanisms excelling by far the precision attained in any other parts regularly produced for our machinery. It has required scientific and untiring attention to detail to develope the processes of heat treatment, manufacturing methods and machinery as well as careful inspection and testing devices. These all contribute to the high quality built into these bearings and enable their makers to produce them at what seems to me so reasonable a cost. Perhaps their ingenuity will yet enable them to go further and produce the same high quality of bearings at even lower cost and so this will greatly assist in promoting the use of them in industrial motors.

In conclusion, I repeat, the question as I see it is—"Do ball and roller bearings offer advantages in general-purpose motors sufficient to justify their added cost?"

Ball Bearings

By L. A. Hillman*

Presented Nov. 10, 1924

TAKEN in the order of their adoption, bearings are usually divided into three classes, namely, plain, roller and ball, the two latter being usually referred to as "anti-friction bearings." The bearings of each group are adapted to the carrying of both radial or thrust loads or combinations of the two.

Plain Bearings

Reviewing briefly the early stages of civilization, we find recorded as early as 3500 B. C. a simple form of plain bearing in a wheel, probably being a slice of a tree trunk with a hole in the center.

Later the design was brought more nearly to our present standard by the introduction of spokes so that in 2000 B. C. we find war chariots equipped with wheels having a hub, spokes and outer rim.

Another use of the simple form of plain bearing was in the pulley which we find used as early as 875 B. C.

In all probability both members of these early bearings were made of wood. The next step, although the definite date is not available, was undoubtedly the use of iron for at least one and possibly both members of the bearing.

With the advent of steel, iron boxes and steel shafts came into common use and for years no attempt was made to improve on this combination which served admirably for the operating conditions in those early days.

In 1839 Babbitt patented a bearing metal which still bears his name, made of copper, tin and antimony. The development of plain bearings from then on is more or less familiar to all.

Roller Bearings

In the early ages masses which were too heavy to carry were transported on sledges or runners—a method we still find in use today among primitive tribes.

It is easy for us to conceive the next step, namely, the interposing of rollers, probably made of tree trunks or limbs, between the ground and the skids.

As in the case of the plain bearings, although the principles of rollers were understood and their advantages appreciated, they were used only in crude ways until the latter part of the 19th century when demand brought about their further refinement and development.

Ball Bearings

We find no reference to ball bearings in the early ages of civilization. Even though their advantages may have been appreciated, they were probably confronted with the same problem which perplexed the experimenters in the 18th and 19th centuries, namely, that of making steel balls. Not until Hoffman developed a process during the last few years of the 19th century for making steel balls to remarkably close limits of size, did the ball bearing really get its start.

The oldest reference to ball bearings which the writer has been able to find is a patent for a ball bearing wagon axle taken out in England in 1794. This is especially interesting and was undoubtedly far ahead of its time. It is in many respects the same as bearings designed as ideal 100 years later.

Another early application of ball bearings is that of balls used in a castor to facilitate the turning of the castor roller around a vertical axis. A patent was taken out on this in Englnd in 1820. It is interesting to note also that the advantage of keeping the balls separated by means of a retainer was appreciated.

The next step in the development of ball bearings came soon after the invention of the bicycle in the form of cup and cone bearings, and this type is still in use today, not only in bicycles and motorcycles but also in applications where the loads are not severe and where cost is a factor. In the early days of the automobile many cars used them as front wheel bearings. For years the balls were placed loosely in the races, but later retainers were developed to space the balls equally

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and maintain their relative position to each other.

These retainers served both to quiet the bearing in its operation and to facilitate the disassembly and assembly of the balls in the bearing.

Properly designed, installed and cared for these types served their purpose admirably. The one outstanding disadvantage is the fact that they are adjustable. Because of this their reputation suffered at the hands of those who did not understand their proper adjustment.

Difficulty was also encountered because of the fact that proper steel, from which to make the bearings in the early days, was not available and it was also necessry to keep their costs down in order to compete with plain bearings.

This simple little experiment may appeal to those who are interested in comparing the relative qualities of the three types of bearings. Assume that the two members of a plain bearing are rolled out into flat surfaces. Compare the friction between the two—first, when moved upon each other in a dry state and, secondly, when lubricated. Then interpose two or more rollers and note the difference even when lubricant is not present. Lastly place several balls between the surfaces and note the action.

Ball Bearing Development During the Last 25 Years

The first use of ball bearings in bicycles was in the early 90's and those bearings were of the cup and cone type. The bearings were of ample size for the service imposed and the results obtained contrasted so favorably with those experienced with plain bearings that immediately attempts were made to apply the same design to other and heavier forms of service, such as the wheels of heavy trucks, drays, etc. Results were far from encouraging—some applications worked fairly well; some were utter failures.

Fortunately, the failures were analyzed as being due to improper materials, design, etc., and not to basic principles involved, so that instead of dropping the problem as hopeless, those men of vision set about correcting the faults and attaining success.

Hoffman had gone to England where he had interested capital in the manufacture of balls and it was evident from results that balls of a good quality and high degree of accuracy could be made.

In 1896 the German Small Arms and Ammunition Co. employed Professor Strieback to investigate the subject of ball bearings, the former having decided to go into the manufacture of balls and ball bearings.

Professor Striebeck's work really marks the start of ball bearings as we know them today and much of their success is due to the fact that he did the task assigned to him with characteristic thoroughness. Many of his deductions have proven to be sound and still hold good today.

The first radial ball bearings were the full type, so called because the races were entirely filled with balls, a small clearance being left so as to prevent the balls from crowding and locking the bearing. The balls were assembled between the races by means of a filling slot. This slot was not ground quite to the center of the ball track so that the slight shoulder over which the balls had to be forced served to prevent them from coming out when the bearing was in operation or should it be mounted on a vertical shaft with the slot opening downward.

Retainers Inserted

This type of bearing was manufactured by several companies for years and gave reasonably satisfactory service. Some were made with a piece of steel inlaid in the filling slot and held in by means of a screw, as it was found that after the bearings wore in service there was a tendency for the balls to drop out of the filling slot. However this scheme was soon discarded.

The full type bearings aside from the filling slot objection had several other disadvantages. There being a slight space between the balls the bearing in operation was noisy for the same reason the cup and cone bearing was and this was especially so if the lubricant was thin.

Also at the points the balls contacted with each other they were traveling in opposite directions and their relative speeds being great, flats or equators were worn around their circumferences after which they were unfit for satisfactory operation.

Although it was appreciated that to

provide a means to prevent the balls from coming in contact with each other meant a few less balls and therefore a sacrifice of some capacity, at the same time the demand for a silent and more satisfactory type of bearing prevailed and various means were adopted to space or separate the balls equally around the race.

One of the earlier types of separators was the spring type. This was finally discarded because after the tension weakened in the springs there was a tendency for them to drop out of the bearing and either allow the bearing to collapse or to lodge in some of the other parts of the mechanism such as gears and cause damage.

Finally retainers were developed such as cast bronze or sheet metal which were unit in construction and which in addition to spacing the balls had the added advantage of preventing the balls from dropping out of the filling slot.

The Conrad type bearing patented in 1906 and 1907 is worthy of consideration because it is the best all purpose radial bearing as yet developed. The patent covered a bearing in which the inner and outer races were uninterrupted in any way and were of the same cross section throughout. It also covered the method of assembly of the bearing. Just enough balls were used to fill half of the raceway when placed so as to touch each other.

To assemble the bearing the outer and inner races were placed in position and the balls filled in through the opening at the bottom. The inner race was then brought concentric with the outer and the balls equally spaced. The retainer was then assembled the same as in any other type.

Although it appears that the carrying capacity of this bearing would be greatly lessened by the considerable decrease in number of balls as compared to the filling slot type, at the same time it is not in direct proportion because the uninterrupted raceways of the Conrad type added decidedly to its ability to carry loads. Thrust loads in addition to radial are often carried on radial bearings and in the type with the filling slot, this causes ball interference with the edges of the filling slots, resulting in noisy operation and failure. These difficulties are not met in the Conrad type because of the uninterrupted races for the balls to travel.

So today we have as survivors of the development of radial ball bearings, the cup and cone type, full type, notched type with retainer and Conrad type. In addition we have the angular contact which is nothing more than a modification of the cup and cone—some are made so they readily disassemble; others are held together by means of a slight shoulder. Practically all of these are made in double row as well as single row.

A few types with patented features are a self-aligning type which permits of a considerable degree of misalignment of the shaft and a type of single row with a two-piece outer race held in place by a soft steel shell spun in place. This type has three point contact of the balls and races, one on the inner and two on the outer. Another type made only in the double row has the outer race made in two sections and held in place with a soft steel shell spun down on the sides.

Ball Thrust Bearings

Early ball thrust bearings were made of two hardened steel plates; the surfaces being ground flat; the walls being held in proper position by means of a retainer. This type is still in use today where the loads are light and where an inexpensive bearing is required.

The first retainers were so designed that the balls tracked in one single path. As this threw all the load on a very small area of the races, special retainers were used in order to distribute the area of contact as much as possible.

It soon became evident that the new retainer design of the flat disc type was not satisfactory to carry heavy loads especially where the higher speeds were a factor. The next step was the grooved type. Many different kinds and types of retainers have been devised for use with this type of thrust bearing, but a pressed steel type seems to have proven the most satisfactory.

Roller Bearing Applications to Industrial Uses

By ARTHUR H. WILLIAMS*
Presented Nov. 10, 1924

THE automobile has probably done more to develop ball and roller bearings and to establish their reliability than any other application. It has also served to bring about volume production of bearings on a very large scale with the consequent reduction of the prices of bearings to a point where their application to other fields presents great possibilities.

With the increased cost of labor and material, the engineer is called upon to design machinery requiring less skilled operation, less maintenance, and at the same time have a greater capacity and longer life. To reach these ends he is turning more and more to anti-friction bearings.

Bearing manufacturers maintain engineering staffs to co-operate with bearing users, so as to secure the most satisfactory application of their bearings. The more manufacturers realize this and co-operate with bearing engineers, the more successful will be the installations that are made. Many of the failures of bearings have been due to faulty applications. A large amount of these have been due to lack of knowledge on the part of the user of the necessary care in machining of component parts, improper fitting, lack of provision for sufficient lubrication, and of improper grease or oil for the lubrication.

For example, a well known motor car manufacturer experienced trouble with pinion shaft bearings. They ran hot and wore out rapidly. Investigation showed that the cone of the front bearing was supposed to be a light press fit to permit adjustment, but went on so tight that no adjustment could be made. The bearings were as tight as the man on the arbor press could pull them up. The result was that the bearings ran hot causing the grease to run out. Without lubrication, and overloaded, the bearings wore out very rapidly. Had the automobile engineer and the bearing engineer worked out their tolerances together they would have found the trouble before it got out into the field. A slight change in tolerance was made and no further trouble was experienced.

Fitting processes for different bearings vary greatly. For instance, a deep-groove ball bearing must not have a tight press fit on either the inner or outer race. The running clearance of the balls is so little that any expansion or contraction of the races will severely overload the bearing, and cause an early failure. With ball or roller bearings of the adjustable type, the revolving member is generally a good press fit, and the stationary member a creeping fit to allow for adjustment. If the cup is mounted in a cup carrier, it also can be pressed in. Some roller bearing manufacturers recommend a press fit for all cups to counteract the bursting action caused by the thrust of the rollers.

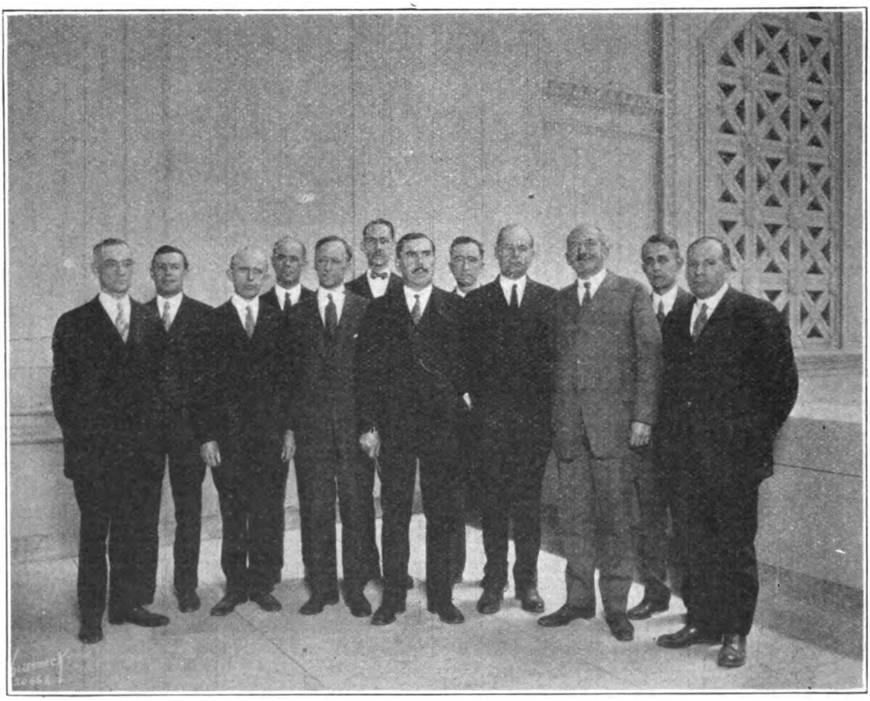
Load capacity of the bearing cannot always be determined from a table because of so many unknown factors such as shocks, reversal of loads, distortion, shaft whip, possible misalignment, and other causes that may come up. For this reason, most bearing engineers prefer to make recommendations on past practice. Where bearings are to be installed by millwrights or shop mechanics they are likely to be abused while being installed. For this reason, bearings going into such hands should be made as near foolproof as possible, even to the extent in some cases of making the entire assembly a detachable unit which need not be dismantled to be put on or taken off of the shaft. Careful instructions should be issued in the mounting of bearings to be sure that they are pressed on or pulled off, for in many shops the sledge is often nearer than the arbor press or the wheel puller.

Because the industrial field is so large and covers such diversified classes of ma-

*Chief Engineer, Shafer Bearing Corporation, Chicago, Ill.

NEW MEMBERS—Continued

218	John W. Rowley	1243 Railway Exchange Bldg.	Associate
219	Robert P. Petersen	4118 N. Parkside Ave., Chicago	Student
220	Robert F. Lyons	118 E. 26th St., Chicago	Student
221	Meyer Louis	1855 S. Troy St., Chicago	Student
223	Louis N. Hitchcock	7412 Vincennes Ave., Chicago	Member
224	William T. Blunt	70 Cuna St., St. Augustine, Fla.	Member
226	Scott R. Conwell	456 Deming Pl., Chicago, Ill.	Student
227	John F. Rithmiller	456 Deming Pl., Chicago, Ill.	Student
228	L. B. Kordell	2639 Armitage Ave., Chicago, Ill.	Junior
230	H. B. Palm	2140 Burling St., Chicago, Ill.	Student
231	Donald J. Braden	6237 Ingleside Ave., Chicago	Student
232	C. G. R. Johnson (Trans.)	Norman, Okla.	Junior
233	Otto Brouk	118 E. 26th St., Chicago	Student
234	John W. Webster	113 Jersey Ave., Joliet, Ill.	Member
235	Raymond S. Knapp, (Transfer)	11066 S. Irving Ave., Chicago	Member
236	Charles M. Davison	6 S. Grant St., Hinsdale	Associate



This issue of the Journal concludes the notable series of papers on the Chicago Union Station. The authors of those papers modestly gave the credit to others for the success of the work described by them. The accompanying photograph shows a group of the men to whom the credit should be given. They are the engineers actually in charge of building the station and the authors of all these papers are in this group.

TECHNICAL PAPERS

JOURNAL OF THE
WESTERN SOCIETY OF ENGINEERS

Volume XXX JANUARY, 1925 Number 1

Bearings for Horizontal General-Purpose Motors

By Howard Maxwell*
Presented Nov. 10, 1924

We present herewith abstracts of three papers covering the principal types of bearings and their application in industrial uses. It is impossible to present all of the illustrations which were used at that meeting but the text describes the types so that their explanation is clear. These papers present the result of years of experience and investigation on the part of different manufacturers and may be said to fairly represent the opinions of those who are best qualified to discuss the respective subjects. —Editor.

During the past twenty years the motor designers have endeavored to substitute ball or roller bearings for sleeve bearings for certain kinds of service and in certain types of machines. It is safe to say that the extent of their progress in this direction has been in direct proportion to the success attending their efforts in the use of these types of bearings. The most ardent proponents of ball and roller bearings have been impatient at times over what seemed to be the slow progress made in introducing these bearings into general motor use, but I think that even they would agree with me that if ball and roller bearings had been applied to all motors 15 or 20 years ago with the limited knowledge and experience available at that time, that the results would have been very detrimental to the ball and roller bearing interests as well as to the motor industry.

There is today a growing demand for general purpose industrial motors equipped with ball or roller bearings. Many motor manufacturers who have not regularly supplied them heretofore are weighing the need of meeting this demand in their standard lines, so that it is well to consider at this time the progress that has been made in the use of ball and roller bearings.

The greatest assurance of success in the introduction of ball or roller bearings into standard lines of motors at this time lies in the fact that the designers of these bearings now agree on many details on which there was in the past a wide diversity of opinion. Among these details may be mentioned:

Lubrication

It is now agreed on general purpose motors operating below 2000 r. p. m. that a light grease is to be preferred. It forms a better seal against the intrusion of grit. As it is less likely than oil to escape from the housing, it should require less frequent replacement of the lubricant and consequently less attention. One of the principal advantages so far developed for ball or roller bearings over sleeve bearings as heretofore made is in their claimed freedom from oil or grease leak-

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age which finds its way on to the windings of the motor, and causes insulation trouble. In order to make good on this claim where grease is used, it will be necessary to educate the motor users not to overfill the bearings as there is no way to limit the quantity of grease inserted as can be done with oil lubrication where overflow gauges are used to determine the oil level.

Standardizaticn of Sizes

The principal makers of ball bearings during the past year have agreed to a list of sizes of bearings to be used with the different motor ratings. This list combining as it does the knowledge and experience of the many ball bearing engineers into a single recommendation, is of the greatest assistance to motor designers and gives assurance to all, that now we are better prepared to extend the use of ball and roller bearings than we have been heretofore.

This standardization of sizes is of the greatest importance to motor users in that it simplifies the problem of renewal bearings. Most of the ball bearings and some of the roller bearings are now interchangeable with each other, and if motor makers use the same size bearings, or at least the same series of bearings, it becomes very easy to provide for supply parts. For this act of standardization we are indebted to the suggestion and help given by the steel mill engineers.

Assembly

It is commonly accepted that the inner race should be assembled on the shaft under a very light pressure fit such as would be secured where the shaft about half a thousandth, or less, larger than the inside diameter of the inner race. This will prevent it from rolling on the shaft as it alternates from loaded to unloaded side. In addition it is generally recommended further to secure the inner race between a clamping nut and a shoulder on the shaft.

The success or failure of ball bearings is closely allied to the manufacturing tolerances and assembly fits. If an inch cube of steel be compressed so that its length be shortened one ten thousandth of an inch, it is being loaded 2800 lb. With this fact in mind one can picture the effect of any slight inaccuracies which tend to cramp the balls and see that such unnatural loads may very easily exceed the normal capacity of the balls. I am quite confident that ball and roller bearings makers understand and are able to meet the tolerances required. An evidence of their appreciation of the practical side of this is that they now make the ball or roller clearance between raceways a little more free so that we can press the inner race on a shaft where it is a little bit over normal allowance without cramping the balls.

Enclosure

In the details of the enclosing covers at the ends of the bearing housing there may yet be some slight difference in methods of grooving recommended, but even here they all follow along the same general lines.

Ball or roller bearing equipped motors now designed according to the above standardized practice and using the recommended sizes of bearings which are one to three sizes larger than those commonly used before should give satisfactory service. It is no longer a question as to whether ball and roller bearings will or will not work satisfactorily in motors, but rather whether or not the ball and roller bearings offer advantages over sleeve bearings which warrant their general use in the face of greater initial cost of the motor. I will confess that I do not know a simple answer to this question, and I think it will require much more extensive use of ball or roller bearings in general purpose motors than now exists to establish the comparative value of the various claims of superiority. There are several points of comparison which are commonly made which can be intelligently discussed in the light of present experience.

Saving In Friction Loss

I mention this first because it was one of the first claims made for ball and roller bearings. In fact, today these bearings are commonly known and designated as anti-friction bearings. This idea originated perhaps because their static or

starting friction is so low that it was quite natural to assume that they would have little or no friction under full speed. It was a great disappointment to motor designers to find out many years ago when they first equipped their motors with ball and roller bearings that these bearings had about the same friction loss as the oil-ring sleeve bearing. We made very careful tests then, both at no load and with the bearings carrying the load of a heavy fly wheel. In making the load tests the motor with sleeve bearings and fly wheel assembled on the shaft was allowed to coast from full to zero speed without power supply, and a deceleration curve plotted between time and speed. A similar deceleration curve was also taken with the same motor and fly wheel but using roller bearings.

It was found after repeated check tests that from 1800 r. p. m. down to 600 r. p. m. it required 20 minutes with either type of bearing, but from 600 to zero speed the sleeve bearing stopped in 26 minutes and the roller bearing motor stopped in 38 minutes.

There was practically no difference in the friction. Both machines stopped in about the same length of time. Below that the roller bearing had less friction by about 30 or 33%.

Many later tests made at no load on both ball and roller bearing motors indicate that there is no appreciable difference in the friction loss of either type in motors operating at moderate or high speeds. We have taken the trouble to check motors of other than our own make equipped both with ball and sleeve bearings, and find that they likewise show no difference in running friction loss.

Over-All Length of Motor

When ball bearings were first used many years ago, it was quite common to recommend much smaller sizes, and also lighter series of bearings than is customary today, so that the impression was formed at that time that they afforded a means of shortening up the over-all length of motor because being small in diameter they could be extended further inside the motor.

With the larger bearings now standardized and commonly used, the outside diameter of the bearing housing is too large to extend inside the rotor windings. It has been our experience that the length over the bearing housings cannot be made less on the ball and roller bearing motors, at least in the sizes up to 50 hp.

Smaller Air Gaps

It has been proposed to reduce the radial clearance or so-called air gap between the rotating and stationary members of a motor where ball or roller bearings are used, and therewith rearrange the design to reduce the cost or improve the motor characteristics and thereby profit by this reduction. The air gaps now commonly used in induction type of motors are now quite small and are generally thought to be the minimum required by considerations other than bearing wear or clearance. They vary from about 10 or 12 mils on a 1 hp. motor up to about 30 to 35 mils on a motor of 50 hp. capacity.

I have yet to find a designer who had courage to make the clearance much smaller with any kind of bearings. On direct-current and synchronous motors the air gap clearances are much larger, but they are set by electrical requirements and would not be made smaller with other types of bearings.

Maintainence Costs

When we take up the subject of maintainence costs we will find data presented and opinions expressed by those using motors in certain classes of service which prove a very considerable advantage on the side of ball and roller bearings over sleeve bearings. This advantage appears in motors used in foundries, steel mills, cement mills and other locations where the air is laden with gritty dust. I believe that this kind of service offers the most promising field for the immediate extension in the use of ball or roller bearing general purpose motors.

It is not argued that ball and roller bearings suffer less from the effects of grit in the lubricant but rather that the form of enclosure and the use of grease

instead of oil prevent the entrance of grit into their housings. The designers of ball and roller bearings have thus indicated to the designers of sleeve bearings the need of more attention to dirt seals and in the past several years this detail has received more intelligent consideration so that the modern sleeve bearing motor is much improved over its predecessors in this respect. It is often contended that the present comparison of bearing life in dirty places is based on old designs of sleeve bearing motors but it still remains for sleeve bearing designers to prove that their bearings are or can be made equal to ball and roller bearings in this respect.

Where the bearings fail and have to be replaced every few months as has been reported occasionally the maintainence cost runs into very large figures each year, and it then overshadows all other considerations. In plants suffering acutely from such trouble I do not expect those responsible for maintainence to give much weight to other points favoring sleeve bearings. However the number of motors located in such extreme conditions of grit-laden air are few as compared with the many in comparatively clean air and thus the importance of this advantage becomes less when considered for a complete line of general-purpose motors.

Oil Leakage

The escape of the lubricant from the bearing enclosure of sleeve bearing motors also is largely a question of the design, and manufacture of the housings.

A certain amount of this kind of trouble is due to careless filling of oil wells. The oilers frequently spill oil over the outside of the motor and many of them too often add oil when the motor is running. It seems possible that more trouble may arise due to too frequent oiling of motors than due to lack of attention causing the oil wells to run dry. So much has been said along this line recently that I have been watching a 15-hp. motor which runs continuously and which has been operating now for nine months without addition to or change of oil. Judging from the amount of oil that has evaporated or escaped in any way I would expect the motor to run another year without adding oil. This motor is not special in any way, it is equipped with the present standard design of sleeve bearing.

I think that as soon as we collect more data, the designers of plain bearings should start a campaign against over-lubrication. It is not safe to do this today because I do not believe we know how long the bearings can operate without renewal or replacement of the oil well enough to advise our customer on this point.

I think too much insulation trouble has been charged to the effect of oil on windings. While oil does tend to soften some kinds of insulating varnish and may in certain bad cases be the prime cause of insulation failure still I do not think it is as serious generally as some people have been led to believe.

Whether or not ball and roller bearings have and can maintain a just claim to advantage over sleeve bearings in this respect hinges on whether the attendants over fill them with grease. When grease is inserted through a plug or pressure fitting there is no indication that the proper amount of grease has been applied until it appears at the openings around the shaft. It is our observation that ball bearings are also generally over-lubricated. Grease is surely as detrimental as oil to the insulation of all coils.

Life of Bearings

It would require a great deal more data than I have available and in fact than I believe is available any where intelligently to compare the life of sleeve with ball or roller bearings used in motors. We know of a few ball and roller bearings motors that were built 10 to 15 years ago and are still running satisfactorily. We also know of some of the first induction motors sent to one of the southern textile mills more than thirty years ago which have run continuously every day and also much of the time at night at constant overload of 25% and in which a recent investiga-

tion showed that 6 motors out of the 14 were running on their original sleeve bearings.

All this is interesting but it does not add much useful knowledge on the life of bearings. We need to know what percentage of bearings, ball, roller or sleeve fail the first year, what percentage the second year and so on but such data are not available for motor applications.

I have mentioned the life of bearings in order to bring out a point which has often occurred to me when considering ball and roller bearings. The journal of a sleeve bearing runs on a film of oil which separates it from the bearing surface, and under ideal conditions there can be no wear or deterioration in the bearing or journal and under such conditions its life is therefore infinite. In a ball or roller bearing the parts are in metal contact and are subject to rapidly repeated stresses which deform the surface and bring into operation the laws of fatigue of metals. These laws teach us that metals subject to repeated stresses eventually break down after a given number of repetitions of the stress, depending upon magnitude of the maximum stress. Therefore ball and roller type of bearings do have a certain definite useful life.

This is not an argument against the use of ball or roller bearings in itself, but simply emphasizes the necessity of selecting ball or roller bearings large enough to avoid the overstressing of the parts.

I was very much pleased to find reference to this in a paper by Mr. Brunner printed in the May issue of the Iron and Steel Engineer, and to realize that the ball bearing engineers had investigated the life of bearings on the basis of fatigue, I believe we can therefore trust that their present day recommendation as to sizes is on a very conservative basis of load rating.

Vibration and Noise

Vibration is more readily carried through a shaft supported on ball bearings than one cushioned on an oil film in a sleeve bearing. This is especially true for such periodicity of vibration as may be encountered with spur gearing and some of the worst cases we have encountered have been severe enough to crystallize the rotor windings. The noise made by the motor also is more noticeable with ball than with sleeve bearings. However, these points can generally be satisfactorily overcome if given proper consideration by the motor designer.

Cost

The difference between a standard horizontal general-purpose motor equipped with ball or roller bearings, and one equipped with oil-ring sleeve bearings, will vary some what with different companies, depending upon the development of their equipment and methods of making sleeve bearings. When expressed as a percentage it will vary considerably with the size and type of motors compared, but I can say with fair degree of accuracy that on the squirrel cage, or most popular type of motor used today, in sizes up to 50-hp. the cost will be increased at least 10% by substitution of ball or roller for sleeve bearings.

We cannot help but admire the ball and roller bearings made today as wonderful mechanisms excelling by far the precision attained in any other parts regularly produced for our machinery. It has required scientific and untiring attention to detail to develope the processes of heat treatment, manufacturing methods and machinery as well as careful inspection and testing devices. These all contribute to the high quality built into these bearings and enable their makers to produce them at what seems to me so reasonable a cost. Perhaps their ingenuity will yet enable them to go further and produce the same high quality of bearings at even lower cost and so this will greatly assist in promoting the use of them in industrial motors.

In conclusion, I repeat, the question as I see it is—"Do ball and roller bearings offer advantages in general-purpose motors sufficient to justify their added cost?"

Ball Bearings

By L. A. Hillman*

Presented Nov. 10, 1924

TAKEN in the order of their adoption, bearings are usually divided into three classes, namely, plain, roller and ball, the two latter being usually referred to as "anti-friction bearings." The bearings of each group are adapted to the carrying of both radial or thrust loads or combinations of the two..

Plain Bearings

Reviewing briefly the early stages of civilization, we find recorded as early as 3500 B. C. a simple form of plain bearing in a wheel, probably being a slice of a tree trunk with a hole in the center.

Later the design was brought more nearly to our present standard by the introduction of spokes so that in 2000 B. C. we find war chariots equipped with wheels having a hub, spokes and outer rim.

Another use of the simple form of plain bearing was in the pulley which we find used as early as 875 B. C.

In all probability both members of these early bearings were made of wood. The next step, although the definite date is not available, was undoubtedly the use of iron for at least one and possibly both members of the bearing.

With the advent of steel, iron boxes and steel shafts came into common use and for years no attempt was made to improve on this combination which served admirably for the operating conditions in those early days.

In 1839 Babbitt patented a bearing metal which still bears his name, made of copper, tin and antimony. The development of plain bearings from then on is more or less familiar to all.

Roller Bearings

In the early ages masses which were too heavy to carry were transported on sledges or runners—a method we still find in use today among primitive tribes.

It is easy for us to conceive the next step, namely, the interposing of rollers, probably made of tree trunks or limbs, between the ground and the skids.

As in the case of the plain bearings, although the principles of rollers were understood and their advantages appreciated, they were used only in crude ways until the latter part of the 19th century when demand brought about their further refinement and development.

Ball Bearings

We find no reference to ball bearings in the early ages of civilization. Even though their advantages may have been appreciated, they were probably confronted with the same problem which perplexed the experimenters in the 18th and 19th centuries, namely, that of making steel balls. Not until Hoffman developed a process during the last few years of the 19th century for making steel balls to remarkably close limits of size, did the ball bearing really get its start.

The oldest reference to ball bearings which the writer has been able to find is a patent for a ball bearing wagon axle taken out in England in 1794. This is especially interesting and was undoubtedly far ahead of its time. It is in many respects the same as bearings designed as ideal 100 years later.

Another early application of ball bearings is that of balls used in a castor to facilitate the turning of the castor roller around a vertical axis. A patent was taken out on this in Englnd in 1820. It is interesting to note also that the advantage of keeping the balls separated by means of a retainer was appreciated.

The next step in the development of ball bearings came soon after the invention of the bicycle in the form of cup and cone bearings, and this type is still in use today, not only in bicycles and motorcycles but also in applications where the loads are not severe and where cost is a factor. In the early days of the automobile many cars used them as front wheel bearings. For years the balls were placed loosely in the races, but later retainers were developed to space the balls equally

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and maintain their relative position to each other.

These retainers served both to quiet the bearing in its operation and to facilitate the disassembly and assembly of the balls in the bearing.

Properly designed, installed and cared for these types served their purpose admirably. The one outstanding disadvantage is the fact that they are adjustable. Because of this their reputation suffered at the hands of those who did not understand their proper adjustment.

Difficulty was also encountered because of the fact that proper steel, from which to make the bearings in the early days, was not available and it was also necessry to keep their costs down in order to compete with plain bearings.

This simple little experiment may appeal to those who are interested in comparing the relative qualities of the three types of bearings. Assume that the two members of a plain bearing are rolled out into flat surfaces. Compare the friction between the two—first, when moved upon each other in a dry state and, secondly, when lubricated. Then interpose two or more rollers and note the difference even when lubricant is not present. Lastly place several balls between the surfaces and note the action.

Ball Bearing Development During the Last 25 Years

The first use of ball bearings in bicycles was in the early 90's and those bearings were of the cup and cone type. The bearings were of ample size for the service imposed and the results obtained contrasted so favorably with those experienced with plain bearings that immediately attempts were made to apply the same design to other and heavier forms of service, such as the wheels of heavy trucks, drays, etc. Results were far from encouraging—some applications worked fairly well; some were utter failures.

Fortunately, the failures were analyzed as being due to improper materials, design, etc., and not to basic principles involved, so that instead of dropping the problem as hopeless, those men of vision set about correcting the faults and attaining success.

Hoffman had gone to England where he had interested capital in the manufacture of balls and it was evident from results that balls of a good quality and high degree of accuracy could be made.

In 1896 the German Small Arms and Ammunition Co. employed Professor Strieback to investigate the subject of ball bearings, the former having decided to go into the manufacture of balls and ball bearings.

Professor Striebeck's work really marks the start of ball bearings as we know them today and much of their success is due to the fact that he did the task assigned to him with characteristic thoroughness. Many of his deductions have proven to be sound and still hold good today.

The first radial ball bearings were the full type, so called because the races were entirely filled with balls, a small clearance being left so as to prevent the balls from crowding and locking the bearing. The balls were assembled between the races by means of a filling slot. This slot was not ground quite to the center of the ball track so that the slight shoulder over which the balls had to be forced served to prevent them from coming out when the bearing was in operation or should it be mounted on a vertical shaft with the slot opening downward.

Retainers Inserted

This type of bearing was manufactured by several companies for years and gave reasonably satisfactory service. Some were made with a piece of steel inlaid in the filling slot and held in by means of a screw, as it was found that after the bearings wore in service there was a tendency for the balls to drop out of the filling slot. However this scheme was soon discarded.

The full type bearings aside from the filling slot objection had several other disadvantages. There being a slight space between the balls the bearing in operation was noisy for the same reason the cup and cone bearing was and this was especially so if the lubricant was thin.

Also at the points the balls contacted with each other they were traveling in opposite directions and their relative speeds being great, flats or equators were worn around their circumferences after which they were unfit for satisfactory operation.

Although it was appreciated that to

provide a means to prevent the balls from coming in contact with each other meant a few less balls and therefore a sacrifice of some capacity, at the same time the demand for a silent and more satisfactory type of bearing prevailed and various means were adopted to space or separate the balls equally around the race.

One of the earlier types of separators was the spring type. This was finally discarded because after the tension weakened in the springs there was a tendency for them to drop out of the bearing and either allow the bearing to collapse or to lodge in some of the other parts of the mechanism such as gears and cause damage.

Finally retainers were developed such as cast bronze or sheet metal which were unit in construction and which in addition to spacing the balls had the added advantage of preventing the balls from dropping out of the filling slot.

The Conrad type bearing patented in 1906 and 1907 is worthy of consideration because it is the best all purpose radial bearing as yet developed. The patent covered a bearing in which the inner and outer races were uninterrupted in any way and were of the same cross section throughout. It also covered the method of assembly of the bearing. Just enough balls were used to fill half of the raceway when placed so as to touch each other.

To assemble the bearing the outer and inner races were placed in position and the balls filled in through the opening at the bottom. The inner race was then brought concentric with the outer and the balls equally spaced. The retainer was then assembled the same as in any other type.

Although it appears that the carrying capacity of this bearing would be greatly lessened by the considerable decrease in number of balls as compared to the filling slot type, at the same time it is not in direct proportion because the uninterrupted raceways of the Conrad type added decidedly to its ability to carry loads. Thrust loads in addition to radial are often carried on radial bearings and in the type with the filling slot, this causes ball interference with the edges of the filling slots, resulting in noisy operation and failure. These difficulties are not met in the Conrad type because of the uninterrupted races for the balls to travel.

So today we have as survivors of the development of radial ball bearings, the cup and cone type, full type, notched type with retainer and Conrad type. In addition we have the angular contact which is nothing more than a modification of the cup and cone—some are made so they readily disassemble; others are held together by means of a slight shoulder. Practically all of these are made in double row as well as single row.

A few types with patented features are a self-aligning type which permits of a considerable degree of misalignment of the shaft and a type of single row with a two-piece outer race held in place by a soft steel shell spun in place. This type has three point contact of the balls and races, one on the inner and two on the outer. Another type made only in the double row has the outer race made in two sections and held in place with a soft steel shell spun down on the sides.

Ball Thrust Bearings

Early ball thrust bearings were made of two hardened steel plates; the surfaces being ground flat; the walls being held in proper position by means of a retainer. This type is still in use today where the loads are light and where an inexpensive bearing is required.

The first retainers were so designed that the balls tracked in one single path. As this threw all the load on a very small area of the races, special retainers were used in order to distribute the area of contact as much as possible.

It soon became evident that the new retainer design of the flat disc type was not satisfactory to carry heavy loads especially where the higher speeds were a factor. The next step was the grooved type. Many different kinds and types of retainers have been devised for use with this type of thrust bearing, but a pressed steel type seems to have proven the most satisfactory.

Roller Bearing Applications to Industrial Uses

By ARTHUR H. WILLIAMS*
Presented Nov. 10, 1924

THE automobile has probably done more to develop ball and roller bearings and to establish their reliability than any other application. It has also served to bring about volume production of bearings on a very large scale with the consequent reduction of the prices of bearings to a point where their application to other fields presents great possibilities.

With the increased cost of labor and material, the engineer is called upon to design machinery requiring less skilled operation, less maintenance, and at the same time have a greater capacity and longer life. To reach these ends he is turning more and more to anti-friction bearings.

Bearing manufacturers maintain engineering staffs to co-operate with bearing users, so as to secure the most satisfactory application of their bearings. The more manufacturers realize this and co-operate with bearing engineers, the more successful will be the installations that are made. Many of the failures of bearings have been due to faulty applications. A large amount of these have been due to lack of knowledge on the part of the user of the necessary care in machining of component parts, improper fitting, lack of provision for sufficient lubrication, and of improper grease or oil for the lubrication.

For example, a well known motor car manufacturer experienced trouble with pinion shaft bearings. They ran hot and wore out rapidly. Investigation showed that the cone of the front bearing was supposed to be a light press fit to permit adjustment, but went on so tight that no adjustment could be made. The bearings were as tight as the man on the arbor press could pull them up. The result was that the bearings ran hot causing the grease to run out. Without lubrication, and overloaded, the bearings wore out very rapidly. Had the automobile engineer and the bearing engineer worked out their tolerances together they would have found the trouble before it got out into the field. A slight change in tolerance was made and no further trouble was experienced.

Fitting processes for different bearings vary greatly. For instance, a deep-groove ball bearing must not have a tight press fit on either the inner or outer race. The running clearance of the balls is so little that any expansion or contraction of the races will severely overload the bearing, and cause an early failure. With ball or roller bearings of the adjustable type, the revolving member is generally a good press fit, and the stationary member a creeping fit to allow for adjustment. If the cup is mounted in a cup carrier, it also can be pressed in. Some roller bearing manufacturers recommend a press fit for all cups to counteract the bursting action caused by the thrust of the rollers.

Load capacity of the bearing cannot always be determined from a table because of so many unknown factors such as shocks, reversal of loads, distortion, shaft whip, possible misalignment, and other causes that may come up. For this reason, most bearing engineers prefer to make recommendations on past practice. Where bearings are to be installed by millwrights or shop mechanics they are likely to be abused while being installed. For this reason, bearings going into such hands should be made as near foolproof as possible, even to the extent in some cases of making the entire assembly a detachable unit which need not be dismantled to be put on or taken off of the shaft. Careful instructions should be issued in the mounting of bearings to be sure that they are pressed on or pulled off, for in many shops the sledge is often nearer than the arbor press or the wheel puller.

Because the industrial field is so large and covers such diversified classes of ma-

*Chief Engineer, Shafer Bearing Corporation, Chicago, Ill.

chinery it is impossible for one type of bearing to cover the field. There are two classes of roller bearings, namely, adjustable and non-adjustable. Non-adjustable bearings are made in several types and use cylindrical rollers, either solid or spirally round. In some cases a flange is added which enables the bearing to take thrust in one or both directions. Of the adjustable bearing there are two common types. The tapered roller bearing, in which the taper of the cup, cone and rollers meet at a common apex on the axis of the bearing, is probably the most familiar. The cone or inner race of this bearing has a flange against which the ends of the rollers bear to take thrust reaction. The other type is of later origin, and of somewhat different principle. The cup and cone of the bearing have convex races. The rollers are concave or hour glass shaped, and run at an angle, determined by the percentage of thrust to radial load. Both thrust and radial loads are taken through the center of the roller, no shoulder being required. The inner race or cone of this bearing is a segment of a sphere thus making the bearing self-aligning and enabling it to take care of any shaft or housing misalignments, and any shaft distortion or whip.

The best bearing to apply at a given point is a matter to be determined by the engineer. In most cases any type of bearing can be used, the question arising which one best suits the requirements of the application at hand. Some of the determining factors that must be considered are treated under the following headings:

Space

Certain applications are largely determined by the space allowable for bearings. With little space between shaft and housing, but with unrestricted length, a non-adjustable type of bearing is required. Again where the overall length of the machine is important the narrowest bearing that will carry the load is required. In this case, practically any type of roller bearing can be used. Often the bearing installation is such that the bearings once installed are very difficult to get at. Here an adjustable bearing would be inadvisable. On the other hand assemblies are sometimes made much simpler and the construction of the entire machine can be simplified by the use of adjustable bearings. These factors must be gone over with the layout engineer.

Manufacturing Practices

The type of machines being built more or less determines the bearing best suited for the application, although no set rules can be given along this line. Generally, however, mill and elevator machinery makers cannot use to advantage as fine a type of bearing as can a machine tool builder whose product is noted for extremely fine workmanship and accuracy, although occasionally rough machinery has been wonderfully improved by the use of high grade roller bearings.

Cost of the Bearing and Its Application

The cost of the bearing is very small compared to the saving that it will make. For this reason, it is well to consider the bearing in the light of manufacturing requirements. One type of bearing may simplify the manufacturing of the product or simplify the design or assembly of the machine. Here again different bearings can show advantages over others. On some applications, where alignment is hard to secure without greatly added expense, the bearing that will take care of slight misalignment has a decided advantage.

Efficiency of Maintenance

It is not alone the saving of power that determines whether to use plain bearings or roller bearings. In many cases the saving in maintenance on large installations is a much greater factor than the saving of power. On the other hand if the saving of power is the primary factor, then the most efficient type of roller bearing should be used, depending on the service to which the bearing is to be put. The efficiencies of different types of roller bearings vary greatly and no set of figures can be given which could be considered absolutely reliable. This is because certain factors come up that have decided influence on efficiency. For example, misalignment of housings or severe deflections of shaft will cause a decided drop in efficiency of a solid roller bearing of either cylindrical or tapered roller type because of pinching of the rollers. On the other hand, this same misalignment

will cause practically no change in the efficiency of a self-aligning bearing. Lubricants used should be of just sufficient consistency to stay in the housings, tor in any anti-friction bearing the principal function of lubricant is to prevent drag of the retainer and to prevent corrosion of the bearings. The class of grinding finish on the bearings is also another factor which will change the efficiency somewhat. A roughly finished bearing of the same type will show less efficiency than a highly finished bearing.

Installation

The mountings of roller bearings vary with different types and should be in accordance with the recommendations of the manufacturers of the bearing to be used. A general principle that should be followed is to make sure that there is ample provision for lubricant. If possible this lubricant should be so supplied that it will be able to circulate or distribute itself throughout the bearing and should the bearing run warm enough to melt, it will not run out. Proper foresight along this line will insure the bearing running over long periods of time with little or no attention. Different kinds of grease retainers are being used, depending on the application. In some installations a felt ring is very satisfactory. This should preferably by run on the shaft and should have just sufficient pressure to create an oil film and prevent the oil working out. Leather cup packings are being used successfully and where water or grinding compound is encountered the felt packing can be used with the addition of some type of labyrinth or slinger positively to throw the water away from the bearing while in operation and so designed as to prevent water from draining into the bearing when not running.

Materials Used in Bearings and the Method of Manufacturing

Practically all roller bearings are made of alloy steel with the analysis varying with different manufacturers, some using straight chrome steel, others using straight nickel steel, and still others using chrome nickel steel. Other alloys have been used successfully. Most of the bearings are made from tube stock because of their general shape. The self-aligning bearing mentioned previously, is one of the exceptions to this rule because of the curved shape of the race. The cup and cone can be trepanned out of solid bar more economically than a bearing can be made of tube stock. General practice in heat treating is to carbonize the parts and harden either with a single or double quench, depending on the service at which the bearing is to be put. The main reason for using carbonized steel is because of the general lightness of the section of the cup and cone and because this structure enables a maximum amount of hardness and at the same time has the greatest ability to withstand shock.

DISCUSSION

M. O. Southworth, M. A. S. M. E.: Fairbanks, Morse & Company made tests to determine the relative values of friction and windage losses on ball-bearing and sleeve-bearing motors with substantially the same results as those found in the General Electric tests reported by Mr. Maxwell, when they were made the same way; that is, running freely, with no pressure on the bearings except the weight of the rotor. There is, as Mr. Maxwell says, very little difference.

But electric motors doing useful work don't run without pressure on the bearings except when connected to the load through a flexible coupling in practically perfect alignment. Belts, gears and chains apply to the motor bearings very considerable pressure.

Belt pressure, chain pressure or gear pressure squeezes the oil film thin on one side. We all know that sleeve bearings (rubbing bearings) frequently run hot when belts are overtight. We all know that hot bearings usually will cool off if the belt is removed and the bearing allowed to run free. This shows that we cannot disregard the matter of bearing pressure.

We wanted to know how much the friction losses of electric motors were reduced by the use of ball bearings when running under load with belts as they do when they are in service, so we belted

a 20-hp., 1800-r.p.m. sleeve-bearing motor to a generator and ran it for fifty hours continuously under full load, measuring the output of the generator and the input to the motor with accurately calibrated watt hour meters just as the power company measures the current that is delivered to a motor over its service wires. Then we put ball bearings on the same motor repeated the test, using the same generator, the same pulleys and the same belt.

In order to eliminate any error due to belt tension the motor was mounted on a base supported at its center on a rocker shaft mounted in ball bearings and a lever arm attached to its base rested on a platform scale. The belt tension was the same for both tests and was maintained constant throughout the tests.

The output of the generator was the same number of kilowatt hours in both tests, so in each test the motor did the same amount of useful work, but the energy consumed by the ball-bearing motor was ten and one-half (10½) kilowatt hours less than that taken by the sleeve-bearing machine.

In a year of 3,000 working hours, sixty times the duration of the test, the saving would be 630 kilowatt hours, and at 3½ cents per kilowatt hour the money saving would be $22.05. The net retail price of the ball-bearing motor is $19.00 more than the sleeve-bearing motor. Therefore, the choice of a ball-bearing motor brings in a more than 100 per cent return on the investment from current saving alone.

An even greater saving may come from the fact that ball-bearing motors do not throw oil into the windings to destroy insulation and that a large part of the expense of oil and oiling is avoided. Ball-bearing motors may be installed on the floor or ceiling without change. They are ready to run at any time without worry as to whether the oil rings will turn or whether there is an adequate supply of oil, and they are not affected by dust. A good ball-bearing motor will run a year without regreasing the bearings and then a few moments' time and a few cents' worth of grease makes them ready for another year of service. The man who ordinarily carries the oil can and watches the motor bearings in a large industrial plant can devote most of his time to other useful work.

Notes On the Relation Between the Capacity of Combined and Storm Sewers, Their Cost and the Frontage Assessment

By S. A. Greeley,* M. W. S. E.

(Contributed)

SEWER service in cities may be divided into the service required to carry off sewage, whether of domestic or industrial origin, and the service required to carry off storm or surface water. Sewers required to carry off domestic and industrial sewage should be provided of ample capacity at any cost, as they concern the public health. There is more leeway in the determination of the desirable capacity of storm water sewers. In cases where surface sewage is carried away in combined sewers, larger capacities are required as a protection to the public health than in the case of separate storm sewers. With combined sewers, basement flooding might bring some sewage into the house if the sewer were surcharged. With separate sewers, surcharge of the storm sewer would back relatively clean water on to the streets. Thus, in the carrying off of storm sewage, there is a factor of convenience as distinct from a factor of public health. Measures of convenience in storm sewer service include the frequency of surcharge and the cost. Installation of sewers for carrying off storm sewage are in the nature of an insurance against inconvenience resulting from ponded streets and to a less extent flooded basements. Thus, the relationship between the cost and capacity of storm sewers is pertinent.

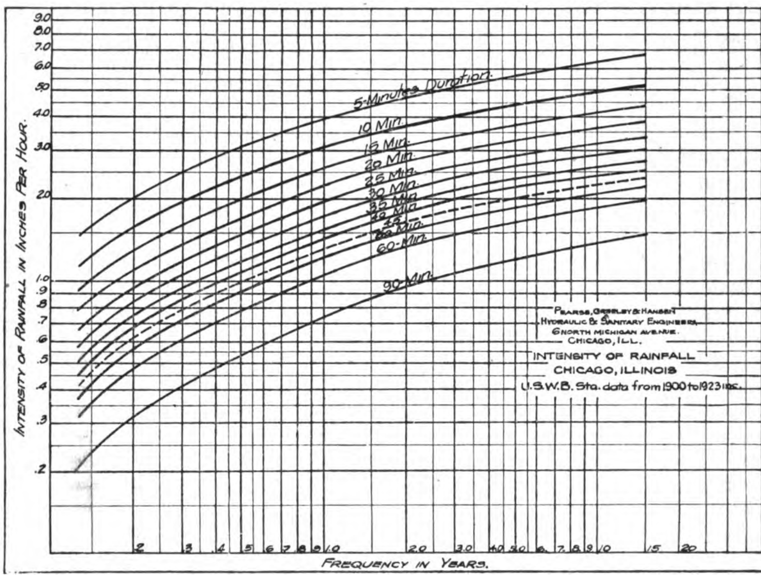
We have recently completed a general plan for new and relief sewers in Decatur, Illinois. Most of the relief sewers to be built are needed to relieve the city of inconvenience from street ponding and to lessen the public health hazard resulting from the flooding of basements through combined sewers. In the beginning of the studies, the principle was laid down that there was some relationship between the cost and capacity of the relief sewers for storm water. Therefore, we undertook by correspondence and visit to ascertain what property assessment or contribution was in common practice for insurance against flooding. Data were secured from ten different cities. The problem may be stated in the form of a question, thus: "What is a fair assessment per front foot or square foot of property served, for storm sewer service?" Combined sewers built in Decatur before the war cost in the neighborhood of $2 per front foot of property, but these sewers were insufficient in capacity so that this measure is not adequate, particularly in view of recent increased costs of construction. The following notes describe the data secured in connection with this project.

*Pearse, Greeley & Hansen, Chicago.

Rainfall

We first made a complete investigation of rainfall intensities and durations in Chicago for the years 1900 to 1923, inclusive, for which period the charts of a tipping-bucket gage were available. These data were plotted to show the relationship between the intensity of the rainfall, the duration of the down-pour and the frequency of occurrence (Figures 1 and 2).

Similar data have been secured and plotted in a number of other communities of which copies were courteously furnished by the engineers in charge. This information was also carefully scrutinized. An effort was made to determine variations in rainfall intensities and frequencies for different districts in the eastern portion of the United States. The purpose of this was to permit the use of available records in the larger cities in the solution of problems in smaller cities where long-term tipping-bucket records are not available. Such records are available at Chicago and St. Louis, but not at Decatur which is about midway between. The results of this investigation are shown on Figures 3, 4 and 5. Figure 3, for instance, shows lines of equal rainfall intensity for storms likely to occur once every three years and for durations by 10-minute intervals from 10 minutes up to 60 minutes. For this storm frequency there appears to be an increased intensity along the Mississippi Valley near the southern boundary of Iowa with a slight depression near the junction of the



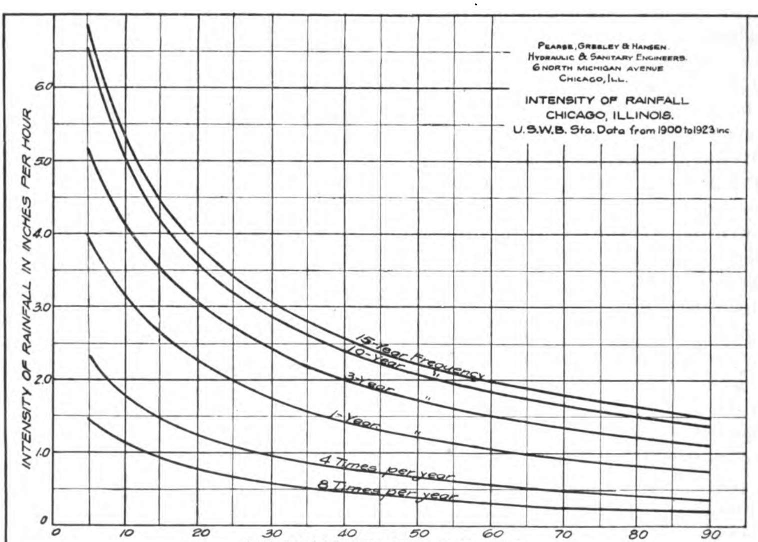


FIG. 1 AND 2—INTENSITY OF RAINFALL AT CHICAGO, ILL.

Mississippi and Ohio Rivers. The intensities then increase along the valley to the Gulf of Mexico.

For the ten year storms the local peak along the Iowa section of the Mississippi Valley is not so pronounced, but the increased intensity toward the gulf is somewhat more marked. For the 15 year storms, much the same comments apply. The rainfall records used in the preparation of these figures were from the following cities:

St. Paul
St. Louis
New Orleans
Chicago
Louisville
Detroit
Columbus
Akron
New York
Boston

It is not held that this distribution of rainfall intensities is final or complete. The data appeared to be of sufficient interest, however, to justify including the charts in this brief paper. Further information and study may result in more complete and useful charts.

Runoff

The amount of rainfall for which storm and combined sewers have been planned was computed in accordance with the zone method as used in Louisville, Ky., St. Louis, Mo., and elsewhere. In accordance with this method, the percentage of impervious surface in districts of various local use were taken as follows:

District	Percentage of Impervious Surface
Mercantile	70
Industrial	60
Commercial	50
Residential (density 16 to 30 per acre)	25
Parks, etc.	10

The city was divided into major districts in accordance with these classifications. The area of each classification in a sewer district was then computed.

The runoff co-efficient was determined in accordance with the duration of rainfall expressed as the time of concentration in the sewer. These co-efficients for impervious and for originally pervious surfaces were estimated as follows:

Time of Concentration Minutes	Runoff Co-efficient For 100 percent impervious surfaces	For 100 percent pervious (originally) surfaces
15	50	20
30	63	30
60	87	43

The runoff co-efficient was determined by combining these co-efficients, using the percentages of impervious and pervious surfaces determined in each sewer district. This computation was developed into the runoff in cubic feet per second per acre for various times of concentration as shown in Figure 6. For main sewers, serving large areas, the resulting runoff was somewhat under 1.0 cubic feet per second per acre. Both of these runoff factors are based on rainfall intensities likely to occur once in ten years.

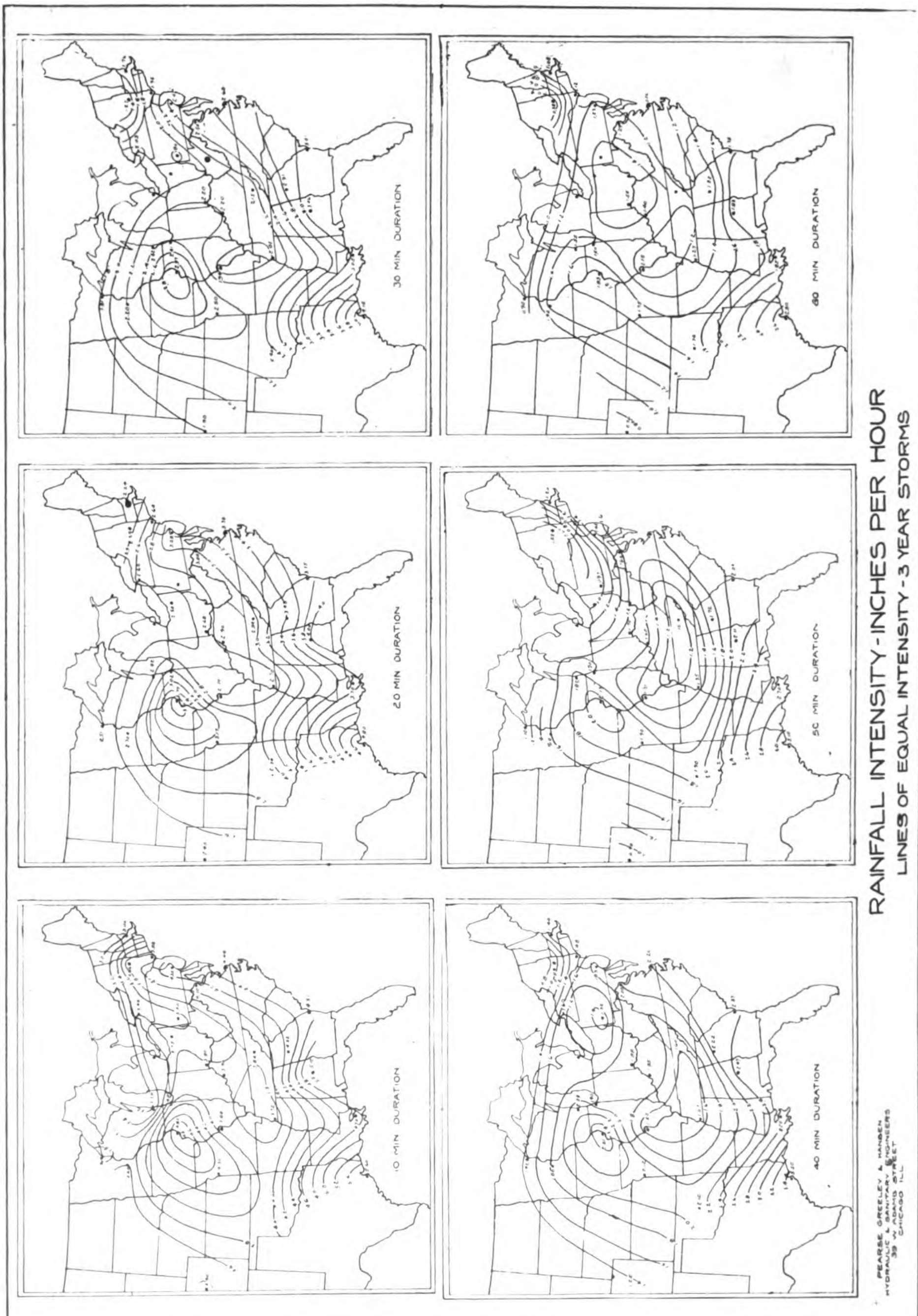
Computations for separate sewers were computed at the rate of 30 gallons of domestic sewage per capita per 24 hours for the future population and the following allowances for other districts:

District	Gal. per acre per 24 hrs.
Mercantile	15,500
Light Commercial	15,000
Industrial	7,800

Computations

In accordance with the foregoing basic data, a special sewer district was selected in the northern part of Decatur, comprising about 525 acres for which a number of sewer systems were designed, including both main sewers and laterals. Alternate designs for combined sewers were computed for rainfall intensities expected to occur once in ten years, once in three years, and once a year. Storm sewers were computed for rainfall intensities likely to occur once in three years, once a year and four times a year. In addition, a system of sanitary sewers was also designed.

The North Sewer District has a length of about 9,000 feet east and west and a width of about 2,500 feet north and south. The main drainage is to the northwest corner of the district. For about one fourth of the area to the south and west the slopes are relatively steep, but in the easterly half the surface of the ground is quite flat. The area is expected to be largely residential with a small proportion in light commercial and park districts. For practically all the area, the percentage of impervious surface was taken at 25. The times of concentration varied from 15 to 50 minutes. The velocities in the sewers varied from 2.0 to 15.0 feet per second, but in general ranged from 3.0 to 4.5 feet per second with the sewers flowing full.


RAINFALL INTENSITY-INCHES PER HOUR
LINES OF EQUAL INTENSITY-3 YEAR STORMS
10 MIN DURATION
20 MIN DURATION
30 MIN DURATION
40 MIN DURATION
50 MIN DURATION
60 MIN DURATION
PEARSE GREELEY & HANSEN
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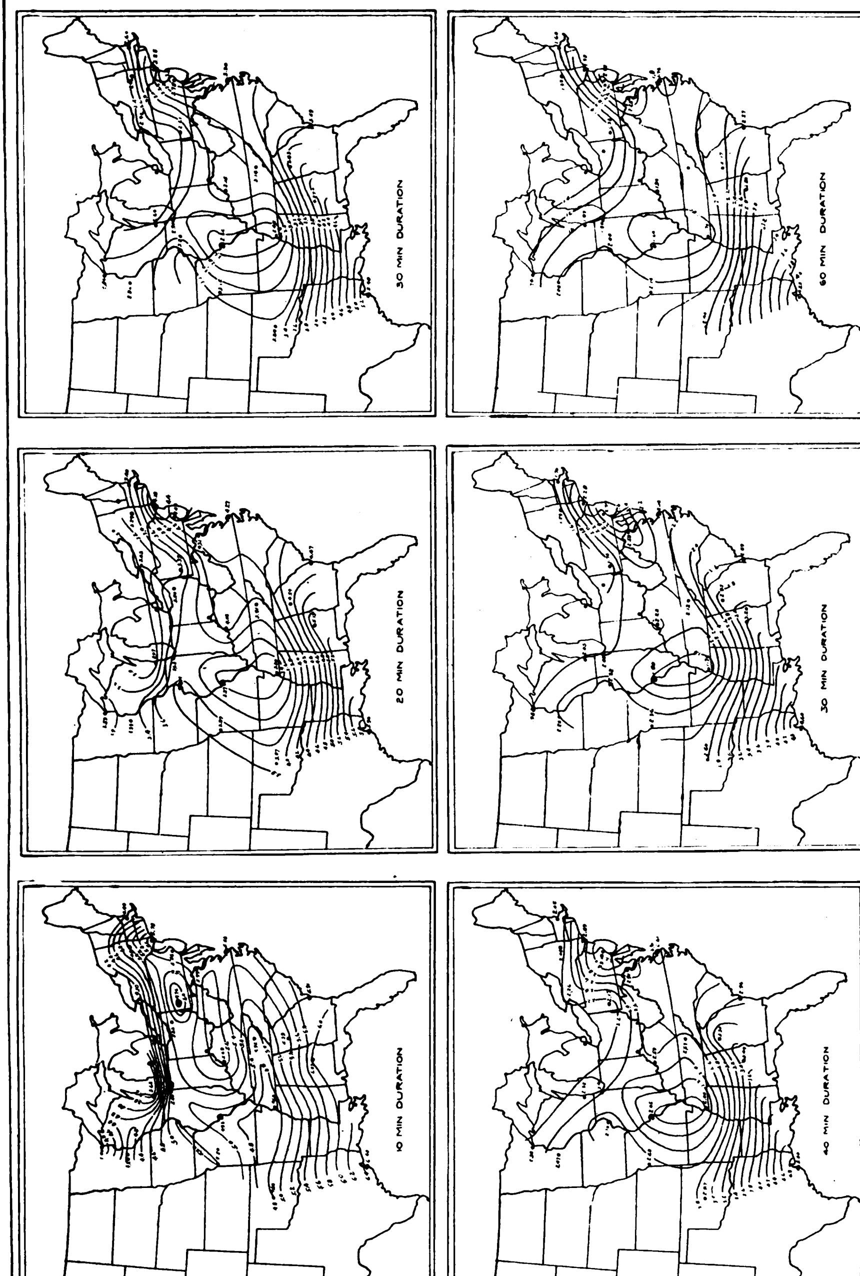
CHICAGO ILL.



RAINFALL INTENSITY - INCHES PER HOUR
LINES OF EQUAL INTENSITY - 10 YEAR STORMS

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HYDRAULIC & SANITARY ENGINEERS
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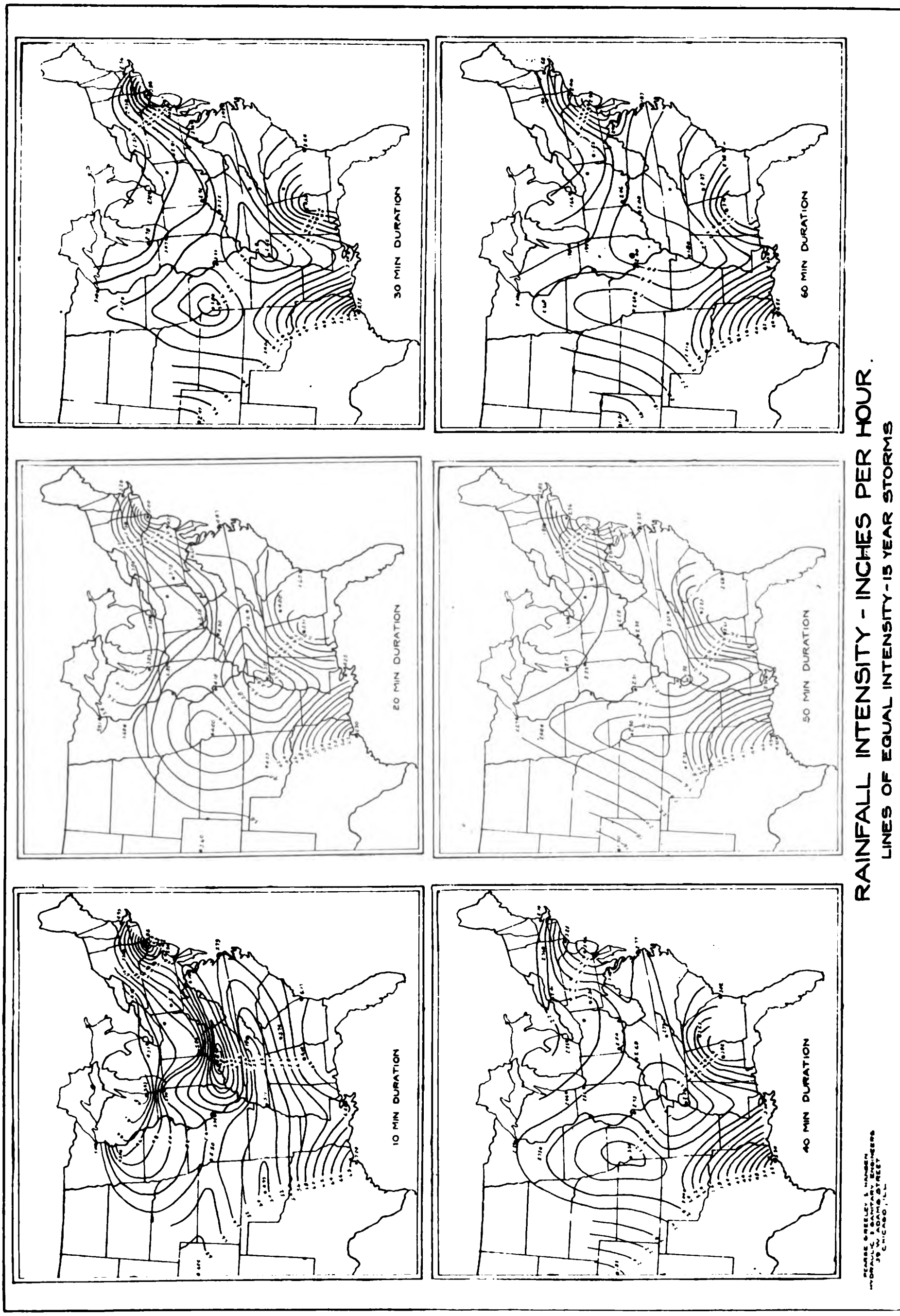
CHICAGO, ILL


RAINFALL INTENSITY - INCHES PER HOUR.
LINES OF EQUAL INTENSITY-15 YEAR STORMS
30 MIN DURATION
60 MIN DURATION
20 MIN DURATION
50 MIN DURATION
10 MIN DURATION
40 MIN DURATION

Costs and Assessments

For each of these various designs, an estimate of cost was made in accordance with the following unit prices per linear foot of sewer:

Diameter of Sewer Inches	Price per linear foot per Av. cut 10 feet
12	$1.90
15	2.30
18	2.95
20	3.35
22	4.00
24	4.50
27	5.65
30	6.70
33	7.50
36	8.15
42	9.25
48	10.25
54	11.50
60	13.00
66	15.00
72	17.50

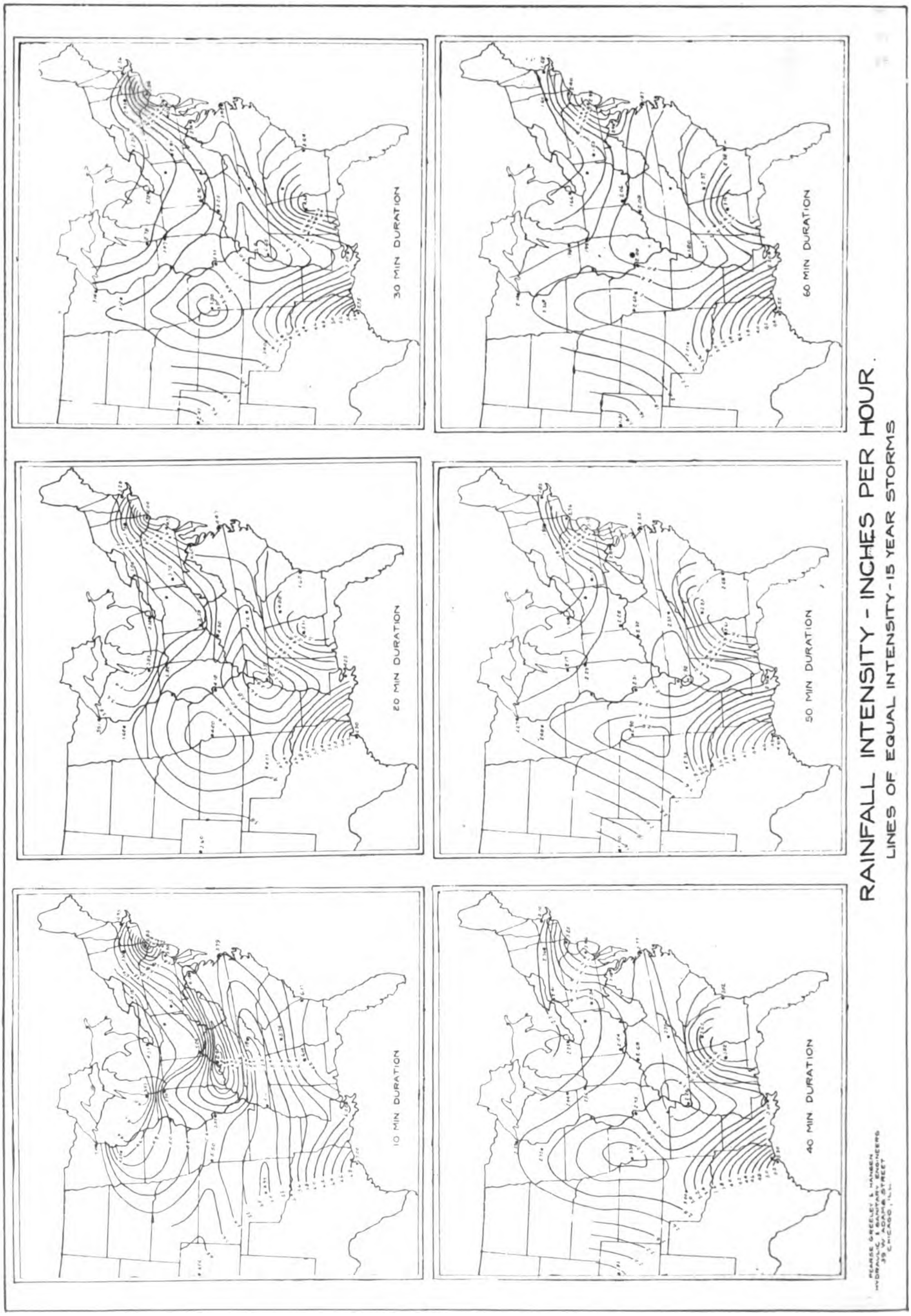
In addition to the foregoing sewer prices, an allowance was made for manholes, street inlets, replacing pavements and railroad crossings.

Table 1 gives the cost of these various sewer systems per front foot of assessed frontage on the basis of 92,000 feet of frontage in an area of 525 acres equivalent to 175 front feet of assessable property per acre of tributary area. The cost of combined sewers for the 10-year rain storm was thus estimated at around $5.00 per front foot. Sanitary sewers were estimated at $1.47 per front foot. A complete separate system including sanitary sewers and storm sewers on the basis of rainfall intensities likely to occur once a year was estimated at $5.36 per front foot. Thus, equivalent costs result with a combined system on a 10-year storm basis and a separate system with capacity in the storm sewers for rainfalls likely to occur somewhat more frequently than once a year.

With reference to combined sewers the difference in cost between the capacity sufficient for a ten-year storm and for a one-year storm was not great, the total costs ranging from $4.00 to $5.00 per front foot or from $160.00 to $200.00 per 40-foot lot. No allowances were made for costs of house connections in separate and combined systems, altho in some instances this is a considerable factor.

TABLE 1
SEWER ASSESSMENT DATA
COST OF SEWERS PER FRONT FOOT AS ESTIMATED FOR THE NORTH SIDE SEWER DISTRICT
DECATUR, ILLINOIS

Projects	Cost of Sewers per Foot of Assessed Frontage			Approximate Capacity of Sewers Cubic Feet per Second per Acre	
	Main Sewers	Laterals	Total	400 acres	100 acres
A. Combined Sewers. Rainfall frequency					
10 years	$2.12	$2.88	$5.00	$ .73	$1.06
3 years	1.78	2.61	4.39	.42	.76
1 year	1.67	2.37	4.04	.38	.57
B. Storm Sewers. Rainfall frequency					
3 years	1.78	2.45	4.23		
1 year	1.67	2.22	3.89		
4 times per year	1.30	1.79	3.09	.19	.28
C. Sanitary Sewers	.26	1.21	1.47	—Capacity 300 gallons per capita and 19 people per acre. Sewers flowing full.	
D. Separate Sewers. (Storm and Sanitary) Rainfall frequency					
3 years	2.04	3.67	5.71		
1 year	1.93	3.43	5.36		
4 times a year	1.56	3.00	4.56		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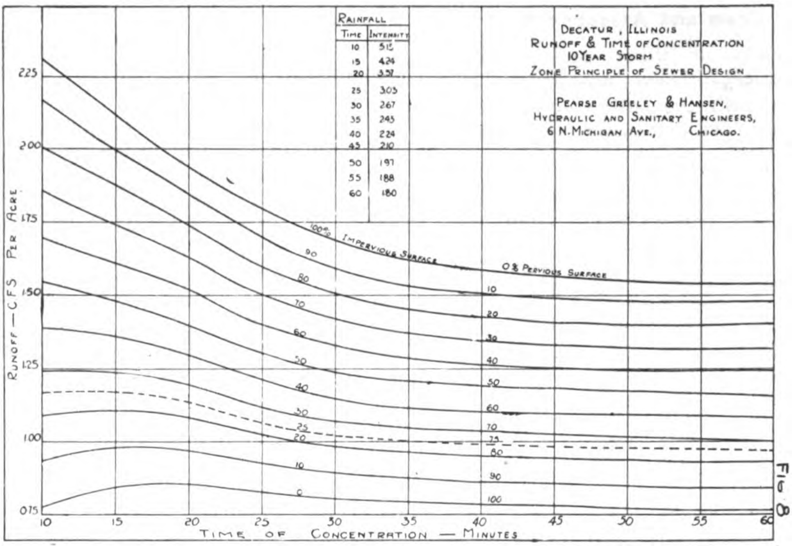

FIG. 6—RUNOFF AS COMPUTED FOR VARIOUS TIMES OF CONCENTRATION

Experience Elsewhere

In order to gain a perspective on the relationship between the cost and capacity of sewers carrying storm water, inquiry was made at a number of cities with results briefly summarized at follows:

a—Louisville, Kentucky

Wolsey M. Caye, designing engineer of the Commissioners of Sewerage, furnished a considerable amount of data by letter. This is summarized in Table 2. Based on 250 feet of frontage per acre of tributary area, costs of combined sewers per front foot of assessable property average about $5.37. If there is only 200 feet of frontage per acre, the average is $6.72.

b—St. Louis, Missouri

Data was furnished by W. W. Horner, Chief Engineer of the Board of Public Works of St. Louis. A visit also was made to St. Louis. Data on the capacity and cost of several sewer districts are shown in Table 3. The average total cost per front foot on the basis of 250 feet of frontage per acre of tributary area is $4.99.

c—Chicago, Illinois

Chicago is served with combined sewers. The ground surface is very flat and the unit capacity of the sewers in residential districts is very low, ranging from .26 c. f. s. per acre from 100 acres to .16 c. f. s. per acre from 500 acres. Total frontage assessments of $4.00 to $5.00 per foot are considered reasonable and are typical of present day practice. Data for several districts are given in Table 4.

d—Indianapolis, Indiana

Charles A. Brown, assistant engineer of sewers, writes that the cost of sewers in Indianapolis varies from $80.00 to $150.00 per lot for an average size lot of 40x140 feet. The average cost for abutting lots would be about $120.00 for lot. This is equivalent to $3.00 per front foot. No specific data were given as to the basis of design.

e—Buffalo, New York

The Colvin Avenue district of 125 acres is considered typical. The assessment for this sewer included a direct frontage charge of $6.00 per front foot and an indirect charge of $13.60 for 1,000 square feet equivalent to around $2.38 per front foot. The assessment therefore amounted to about $8.38 per foot of property assessed.

C. E. P. Babcock, City engineer, writes that the 5-foot sewer (for this

district) was constructed on a 0.2% grade, this having a capacity of about 102 c. f. s., to take care of an area of about 125 acres, represents a design with a rainfall of 2 inches per hour with a run off coefficient of 0.40 in the rational formula. This is a run off of about 0.82 c. f. s. per acre.

f—Milwaukee, Wisconsin

T. Chalkley Hatton, Chief Engineer of the Sewerage Commission, writes that, "The laws of Wisconsin as applicable to Milwaukee provide that the city can only assess for sewers up to $1.25 per front foot and the balance of the cost must come from the general fund. Under present conditions this assessment does not meet the cost. . . We did have, in one of the outlying districts, some time ago, a system plan laid out for one section which included storm water sewers only and, to the best of our information, this system would have cost about $1,000 per acre. This included a very large outfall sewer. . . . "

Storm sewers are based on the rational basis with a rainfall curve approximately a 15-year interval and co-efficients as follows:

	Runoff	Inlet Time
Densely built up commercial districts	70%.	5 min.
Adjoin. Well built up districts	55%	7 min.
City residential districts	30%	10 min.
Suburban residential districts	20%	15 min.

TABLE 2

SEWER ASSESSMENT DATA

COST OF SEWERS PER FRONT FOOT AT LOUISVILLE, KENTUCKY AS REPORTED BY WOOLSEY M. CAYE

District	Tributary Area in Acres			Capacity at Outlet C. F. S. per acre.	Cost per Front Foot		
	Main Sewer		Laterals		Laterals	Mains	Total
30th St.	88.7		27.8	1.51	2.41	2.82	5.23
44th St.	43.		12.2	1.62	1.63	1.98	3.61
Floyd St.	59.1		14.7	2.14	2.32	2.88	5.20
34th St.	114.8		58.3	1.34	4.46	3.23	7.69
Payne St.		15.1		2.38			5.65
Millwood Ave.		44.88		1.80			4.84
				1.79	2.70	2 73	5.37

Notes—The original figures were given in cost per acre. We have used 250 feet of frontage per acre in making the re-computation.

TABLE 3

SEWER ASSESSMENT DATA

COST OF SEWERS PER FRONT FOOT AT ST. LOUIS, MISSOURI FROM DATA FURNISHED BY W. W. HORNER

District	Tributary Area Acres		Capacity at Outlet C. F. S. per Acre.	Cost per Front Foot		
	Main Sewer	Laterals		Laterals	Mains	Totals
Wherry Ave. Joint	574		2.4		$3.33	
Wherry Ave. No. 1		182	2.4	$3.49		$6.82
No. 2		52				4.67
Loughborough	97		2.4	1.34 2.68		
Glaise No. 19			2.4			3.47
North Baden		60	2.4	1.66		
Averages			2.4		$3.33	$4.99

This gives a runoff for city residential districts of about .65 c. f. s. per acre from 500 acres.

g—Detroit, Michigan

Data were furnished by George Jerome, City Engineer. The city is practically all sewered on the combined system. Lateral sewers are laid in the alleys and the cost of construction is assessed directly against the abutting property on an area basis. During 1923 the average rate of assessment amounted to $648.69 per acre or $3.24 per front foot at 200 feet per acre and $2.59 per front foot at 250 feet of frontage per acre.

The basis of design is the rational method using a rainfall curve which for periods above 20 minutes is exceeded once every 10 years.

h—Syracuse New York

In Syracuse the sewers are all on the combined plan and are assessed at the rate of $3.00 per front foot as fixed by law. (Appendix 1). A deficit is made up out of the general fund and this fund holds credits for future construction. The capacity of the sewer is 0.75 c. f. s. per acre in the business districts and 0.50 c. f. s. per acre in all other districts.

i—New Bedford, Massachusetts

Sewers in New Bedford are on the combined system. As in Syracuse, there is a fixed frontage charge, in this case, of $2.00 per front foot. Sewers are all placed on a flat rate of runoff of 1.0 c. f. s. per acre. The actual cost of all combined sewers built in 1922 averaged $5.24 per linear foot of sewer. The assessment per front foot was thus less than half this amount.

j—Los Angeles, California

W. T. Knowlton, Engineer of Sewers, writes as follows: "In reply to yours of March 4, regarding assessments for combined sewers, would advise that as practically all sewers are separate, we do not have much information on assessments for storm drains. When they do occur, the prevailing method is to assess according to area, although some allowance is made for the property having been previously assessed for other sewers when such is the case; furthermore, the assessment varies according to the distance of the property from the work to be done. To illustrate the plan of what is known as the Arroyo de la Sacatela, my own lot where I live has 7,000 square feet and its proposed assessment according to the first plan would be about $100.00, whereas other lots of the same area which are along the work to be done will be assessed two or three times as much, if not more. You will appreciate that the assessment will also vary with the cost of the work."

On the basis of the lots having a 50-foot frontage, this assessment would amount to from $2.00 to $6.00 per front foot.

k—Rochester, New York

E. A. Fisher, Consulting Engineer, writes as follows: "Our method of paying the cost of sewers, either sanitary, storm or combined sewers is to have an ordinance passed for the construction of the sewers and in the ordinance the Council will designate the benefitted territory. The entire cost, except in the case of intercepting sewers connected with the

TABLE 4

SEWER ASSESSMENT DATA

COST OF SEWERS PER FRONT FOOT IN CHICAGO, ILLINOIS AS REPORTED BY BERT HUDSON

District	Tributary Area Acres		Capacity at Outlet C. F. S. per Acre	Cost per Front Foot		
	Main Sewer	Laterals		Laterals	Mains	Totals
Crawford Ave.	5200		.096		$1.75	
Harlem Ave.	430		.175			$4.06
Western Ave.	1030		.136		3.70	
Argyle St.	4200				2.20	Built 1915

Notes—The capacity of combined sewers in Chicago is computed by the formula $Q=CA^{3/4}$, C is generally taken at 0.8 for residential districts.

disposal plant, is borne by the territory draining through the sewers in questior

"The assessors in making the assessment subdivide the territory according to what they consider the benefits. The Council has no authority as to how the assessment shall be levied. That is left entirely to the assessors.

"In the case of Main and Front Streets sewer, to which I have referred, the Council determined the benefitted territory, which included all territory draining into or through this sewer. The assessors divided, upon the recommendation of the engineer, the territory into three districts. The first district included the territory directly benefitted by the deepening of the sewer, and on this small territory 70% of the entire cost was assessed, the estimated cost per front foot being $25.00.

"The second section, which included apartment houses and was not directly benefitted by deepening the sewer, was assessed 20% of the entire cost, or at the rate, as I remember it, of about $4.00 per foot.

"The third, and largest, section, consisting of residences at the upper end of the district where the deepening would not be of any special benefit to them, was assessed 10% of the entire cost or at the rate of about 40 cents per front foot."

Comments on Assessments

Table 5 is an approximate summary of this data. The right hand column is an indication of the trend of the assessments per front foot under construction costs prevalent in 1923. Somewhat over $5.00 per foot is indicated. When the reported data is for storm sewers only, or for laterals only, an allowance has been added to reach a total for a complete service in accordance with the estimates for the north side sewer system in Decatur.

These figures apply to newly developed districts adjacent to older districts fully served with utilities. The lots are considered to have a value because of their proximity to the city and a potentially larger value when utilities have been provided. Thus a 50-foot lot selling without utilities for $750.00 would have an increased value after sewers were installed of around $1,000.00. The assessment for sewer service is thus about one-third of the bare lot value. This assessment is sufficient in Decatur to build sanitary sewers and storm sewers to carry the runoff from storms likely to occur once a year; or combined sewers to carry the runoff from storms likely to occur once in 10 years.

Conclusions

After a consideration of the various factors, it was decided in Decatur that, under

TABLE 5

SEWER ASSESSMENTS

SUMMARY OF APPROXIMATE DATA

City	Kind of Sewer System	Sewer Capacity C. F. S. per acre: 100 acres	500 acres	As Reported	Cost of Equivalent Combined Sewer Service per Front Foot: On basis of 200 ft. per acre	On basis of 250 ft. per acre	Trend
Louisville	C	1.46	1.16		$6.72	$5.37	$5.50
St. Louis	C	2.55	2.44		6.24	4.99	5.50
Chicago	C	0.26	0.16				4.50
Indianapolis	C	0:60 (1)	0.43				3.00
Buffalo	C	0.82		8.38			8.38
Milwaukee	S	.80	0.65	4.00 (2)			5.50
Detroit	C				3.24 (3)	2.59 (3)	5.50
Syracuse	C	0.50	to 0.75	3.00 (4)			
New Bedford	C	1.0	1.0	2.00 (4)			
Los Angeles	S			4.00 (2)			5.50
Rochester	C						
							5.42

Notes—(1) Based on C = .4 and slope of 2/1000.
(2) Storm sewers only.
(3) Laterals only.
(4) Assessment fixed by law

present conditions, an assessment for complete sewer service, exclusive of laterals, of around $5.00 per front foot of property was not unreasonable, and that sewer capacity for the runoff from 10-year storms should, in general, be provided for combined systems. The relation of this assessment to changing construction costs and real estate values was not determined.

APPENDIX I

Sewer Assessments in Syracuse

CHAPTER 303

AN ACT to amend chapter six hundred and eighty-four of the laws of nineteen hundred and five, entitled "An Act to supplement the provisions of law relating to the department of public works of the City of Syracuse," in relation to cost of constructing sewers.

Accepted by the City

Became a law May 1, 1923, with the approval of the Governor.

Passed, three-fifths being present.

The People of the State of New York, represented in Senate and Assembly, do enact as follows:

Section 1. Section fourteen of chapter six hundred and eighty-four of the laws of nineteen hundred and five, entitled "An Act to supplement the provisions of law relating to the department of public works of the city of Syracuse," as amended by chapter one hundred and thirty-one of the laws of nineteen hundred and nine, is hereby repealed and a new section fourteen inserted in place thereof, to read as follows:

No. 14. COST OF CONSTRUCTING SEWERS; ASSESSMENTS AND PAYMENT THEREFOR. The cost of constructing all sewers in the city of Syracuse, the cost of which shall not have been heretofore asserted, shall be assessed and collected by the city at the rate of three dollars per linear foot of property fronting or abutting upon the street or part thereof in or through which such sewer is to be or has been constructed, except that corner lots abutting upon more than one street shall be taxed and assessed only for the shorter foot frontage and the longer foot frontage in excess of one hundred feet.

Where, however, the cost or expense of said sewer exceeds the sum of three dollars per foot frontage, then and in that event the additional cost thereof shall be a charge against the city at large and paid from the permanent improvement account, upon order of the common council; and where the cost of any such sewer is less than three dollars per foot of frontage; such excess shall be collected in the regular manner and paid over by the city treasurer to the said permanent improvement account by reason of the construction of sewers, bonds shall be issued in the regular way for such sum as the city engineer shall estimate to be necessary to cover such deficit. The cost of constructing intercepting sewers, however, shall be borne by the city at large.

No. 2. This act shall take effect immediately.

Port Administration

By F. T. CHAMBERS*

Presented October 27, 1924

Herein is presented a brief summary of the organizations established to control the business of the principal ports of the United States. It is of interest to citizens of Chicago at this time in view of the probable development of the waterborne commerce of the city. Chicago is given as an example of a port without administrative organization.

This paper was presented at the suggestion of the Waterways Committee of the Western Society of Engineers, which is interested in the development of the Port of Chicago.—Editor.

A PORT may, for our purposes, be defined as a harbor so improved as to offer facilities for the transaction of business between ocean and land carriers. The word may be used to designate an entire harbor improved for the transaction of such business, as, for instance, where we speak of the port of New York, thereby including both the New York and New Jersey shores; or the word may be applied to indicate one terminal development within the harbor.

Insofar as American ports are concerned, the interchange between the rail carrier and the water carrier is the principal function, and I like to think of water carriers as prolongations of the operations of rail carriers. At least, the ideal should be to effect the transfer between rail and water in the most expeditious and economical way practicable. The well equipped port will provide pilotage where necessary; tugs for towing ocean vessels to their berths; anchorage for vessels not requiring any berth, with access to shore; piers or wharves, open or covered, affording direct connection between water and land carriers; storage facilities, ranging from open-ground areas for bulk materials which will not materially deteriorate from weather exposure, to loft buildings for the protection of perishable cargo; coal and oil storage, with supporting piers or lighters affording bunkering facilities; repair shops and dry docks, with the necessary capacity and equipment for overhauling and repairing ships, lighters and car floats for the transfer of cargo from various points in and near the harbor to and from ships, accommodations for the direct access of trucks and, in some instances, for canal and river craft, and, most important of all, railroad tracks and yards, properly located, and adequately provided with trackage for storage and transfer of the many full and empty railway cars necessary to handle, to and from vessels, the freight which makes up their cargo. Such facilities may be provided by private individuals or companies, or public corporations, such as the railroads and the steamship companies; by the public; or by a combination of these agencies. In any event, some individual, or combination of individuals, must plan, provide, maintain and operate the necessary plant for the transaction of the waterborne business.

Port Authorities

The modern accepted term for the supervisory body which provides, maintains and operates a port is "The Port Authority," and this is recognized by The American Association of Port Authorities, an organization composed of port operators and port engineers, which meets annually for the discussion of matters of common interest and which publishes in "World Ports" a monthly periodical of port papers and port news.

The body in control of the Port of London is known as "The Port of London Authority." The more recently established New York, New Jersey joint body for co-ordination and future planning of facilities for the port of New

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York is known as "The New York Port Authority" and the agreement between the states creating this body has been ratified by the National Congress.

Examples of Foreign Ports

Since the very life of the British Isles has been for years, and is now, dependent upon ocean shipping, and since the British people are recognized as perhaps the most successful in ocean shipping matters, it is but natural that we should turn first to British practice for authoritative information with regard to port administration; and since we must have some one to plan and manage our port we will first see how the port organizations of principal British ports are constituted. In normal times there is in Great Britain no central control of ports. Authority is wholly local and is administered in each case by an organization chartered by Parliament. In perhaps the majority of cases the administration is in the hands of a so-called trust, such trusts being in reality, corporations operating without profit for the benefit of the individual port. In other cases, the railroad corporations are entirely in charge, and, again, as in the case of the port of Bristol, the entire organization is in the hands of the municipality. When operated by a trust, the board is made up of members of the municipality, of the ship-owning interests, and of the shipping community in general. Such trusts have the power to issue bonds and to fund them by means of the revenues derived from port dues. The ports of London and Liverpool are in the hands of bodies of this nature.

Various Interests Represented

At Liverpool situated on the Mersey, the governing body is the Mersey Dock and Harbor Board, which was established in 1858, by act of Parliament, and has 28 members, 24 of whom are elected by the dock ratepayers—i. e., persons paying rates and dues on ships and goods only—and the remaining four are appointed by the Mersey Conservancy Commission, which consists of the first lord of the Admiralty, the chancellor of the Duchy of Lancaster, and the President of the Board of Trade. The city of Liverpool has no direct jurisdiction. The effort is made in making appointments to the board to give the various trading interests in the local shipping community a proportionate representation. Up to about the year 1910, there was considerable friction among the various factions, due to the efforts of each to obtain a maximum number of positions on the board. Since then, by mutual understanding a proper proportion has been reached and maintained without friction. Only in cases of dissatisfaction at a decision of the local board is appeal even made to the Board of Trade, which is an Executive Department of the Imperial Government and corresponds in part to our Department of Commerce.

That this organization conducts a great business goes almost without saying. It is not within the scope of this paper to indicate in detail the various matters with which the Board has to deal, but those interested will find in a volume entitled "English Port Facilities",* compiled by myself during the world war for the United States Shipping Board, much detail contained in numerous appendices, showing the early history of the port; the history of the various docks; pilotage; buoying; lightering; dredging; etc.; the commerce of the port; a sample of the accounts for an entire year, inclusive of dock duties received; dock tonnage rates; graving dock rates; annual revenues; linear quayage, with depths of water alongside; landing stages; characteristics of graving docks; coaling appliances; petroleum stores; dock warehouses; quay sheds and cranes available for general use

Powers Consolidated in Large Ports

At both Liverpool and London the range of tides is such that the principal terminal facilities are all in basins behind locks. In order that the situation at London may be understood it is necessary to say that London lies upon the River There are river quays, but these are not well adapted to ocean going ships and, as just stated, the principal facilities are Thames some 50 miles from the sea. in basins or docks which must be entered through locks. An account of the various dock systems and of the quarrels between

*Copy in W. S. E. Library.

the several dock corporations, and between these corporations as a body and the wharfingers and lightermen, would require a history in itself. The only point in mentioning them here is that these quarrels finally led to such a pass that, to cure the situation, royal commissions of inquiry were appointed at various times. The last of these was ordered in June, 1900, and submitted a report in 1902. The conclusion arrived at was that the port was in danger of losing a part of its trade. The division of power among different authorities was a drawback. The commission recommended that a new authority be created in which should be absorbed the property, powers and obligations of all the dock companies; of the Trinity House within the limits of the port (the Trinity House being responsible for the lighting, buoying and pilotage of the port); of the Thames Conservancy below Teddington and of the Watermen's Company—the latter an ancient labor guild empowered from early days to license lightermen, a monopoly which had long been the cause of widespread complaint. The commission made other recommendations, included in which was a scheme providing for a new administrative body. The commission's final proposals were coldly received, but the Government in 1903 brought in a bill in accordance with the report of the commission. The bill was dropped, however.

Unsuspected by the city, however, Mr. Lloyd George, then President of the Board of Trade, had been for some time employing accountants to investigate the figures of the dock undertakings. On the basis so obtained, he entered privately in the spring of 1908 into negotiations with the dock companies for the purchase of their property for transfer to a public authority. An agreement having been thus arrived at, the announcement was made that the government had decided to take over the property of the separate companies at a collective valuation of 23,000,000 pounds. A comprehensive bill was introduced in July, 1908, into the House of Commons.

Port of London Organized

This history of the port of London is touched upon, first, because it is believed to be of general interest, and, second, because it goes to show that ports are not co-ordinated and port authorities are not created without difficulty. The government bill transferred the docks to the supervision of a new port body to be known as the "Port of London Authority." Except that the Trinity House is responsible for the lighting and buoying of the river, the metropolitan police are the port's guardians, and the corporation of the City of London supervises the sanitary conditions, the Port of London Authority has charge of everything affecting the port, inclusive of authority to collect tolls on goods. It should be noted here that while the main dock waters, quays and warehouses passed into the hands of the new authority, the river quays and warehouses remained independent undertakings.

The Port Authority has ten appointed members—one by the Admiralty; two by the Board of Trade; two by the London County Council (being members of the Council); two by the London County Council (not being members of the Council); one by the city corporation (being a member of the corporation); one by the city corporation (not being a member of the corporation); and one by the Trinity House. There are 18 elected members, 17 by the payers of dues, wharfingers and owners of river craft, and one by the wharfingers. In addition to the appointed and elected members, the chairman and vice chairman may be appointed from outside the membership the authority, making the total possible number of members 30.

Authorities Cover Entire Districts

I will give one further illustration of a port that is operated under a so-called trust. The City of Newcastle, with a population of 300,000, is situated upon the Tyne, and the full port community on the Tyneside consists of about one and one-half million people. The port body is called the Tyne Improvement Commission, which has general authority over the river, although there are numerous private docks, the Northeastern Railway Company also operating docks of its own. This port authority has 32 commissioners, 15 of whom represent the city cor-

porations of the different municipalities embraced in Tyneside. Fifteen are dues payers—that is, representatives of the coal, shipping, and general traders of the port. Two members represent the Board of Trade. The larger body is divided into committees of (1) Finance; (2) Dredging and river works; (3) Docks; (4) Harbors and ferry, and (5) Parliamentary.

Bristol Has Municipal Control

The port of Bristol is the only one which I inspected in England which is owned and operated entirely by the municipal corporation. The control is vested in the city council, which for purposes of administration appoints a sub-committee which, in turn, employs the executive officials, who are given a free hand in the management of the port. The three dock systems at Bristol are widely separated and the operating staff is constituted accordingly. At the head office in the city of Bristol they have a general traffic manager, a chief clerk, a chief freight agent, a secretary and a collector of dues. At the city docks there is a traffic manager, a superintendent of warehouses, a water bailiff, a quay warden and three dock masters. At the Avonmouth Docks there are a traffic manager, a dock master and a deputy dock master. At the Portishead Docks there are a traffic manager and a dock manager. In the city of Birmingham there is a resident agent of the Bristol docks, and at the engineer's office in the city of Bristol there are a chief engineer and three assistant engineers. There is also a separate havenmaster's office, with a havenmaster.

There are, of course, British ports where the railways have practically entire charge of the dock systems which are their own, and there are others where railways maintain separate systems, although the main system may be publicly owned and controlled. At Liverpool, for instance are the Garston Docks owned and operated by the London and North Western Railway Company.

War Department Controls U. S. Harbors

Insofar as our own country is concerned, the Federal constitution delegated the authority to regulate traffic over the waterways of the United States to Congress, and Congress has in turn delegated most of the essential authority to the War Department, where the Chief of Engineers and his district engineers have the direct control. The War Department then supervises, improves and controls navigable channels and harbors, authorizes bridges over navigable waters, etc. There are other functions of the national government in connection with waterways and harbors, such as regulation of entry and clearance, quarantine, lighting and buoying, exercised by government departments other than the War Department, and it may be stated as a general proposition that the individual states may, and they frequently do, exercise power in connection with the ports and harbors where the national government has not taken charge, or in such cases where there is no conflict between national and state government.

We are, however, more concerned in that part of port administration which deals with the actual operations at the terminal or terminals. Fifty years ago port administration in the United States consisted of little else than policing the harbor and water front. Water terminals for ocean commerce were rarely operated by public authority, and public warehouses and trans-shipment facilities in the modern sense scarcely existed. The creation of a state board of harbor commissioners for San Francisco in 1863, and of a similar state board for the port of New Orleans in 1896 led to the public operation of water terminal facilities in those ports. Legislation by the state of New York in 1871 provided for municipally owned wharves and piers in the port of New York, but under the policy adopted by the city, the operating control of its water front properties has fallen largely into the hands of private interests, by reason of the granting of long term leases. Control other than public exists at many ports where the water front of our harbors has been developed largely by industry or by competing trunk line railroads, each having a separate terminal, and in many cases occupying an undue proportion of the available frontage. As late as 1910, in a report on "Transportation by Water," the statement was made by the U. S. Commissioner of

Corporations that "private interests control nearly all of our active water frontage." Public control in considerable degree was found only at New Orleans, San Francisco, Baltimore and New York. Reference has just been made as to the effect of long term leases at New York. At Baltimore the public control was exercised over a very small section of the water front.

Of late there has been a largely increased tendency towards public control of water front property, and especially is this true in the more recently developed ports. Congress has in fact gone so far as to say in the river and harbor act approved March 2, 1919,

> "It is hereby declared to be the policy of the Congress that water terminals are essential to all cities and towns located upon harbors or navigable waterways and that at least one public terminal should exist, constructed, owned and regulated by the municipality, or other public agency of the state, and open to the use of all on equal terms, and with the view of carrying out this policy to the fullest possible extent the Secretary of War is hereby vested with the discretion to withold, unless the public interests would seriously suffer by delay, monies appropriated in this act for new projects adopted herein, or for the further improvement of existing projects, if, in his opinion, no water terminals exist adequate for the traffic and open to all on equal terms, or unless satisfactory assurances are received that local or other interests will provide such adequate terminal or terminals. The Secretary of War, through the Chief of Engineers, shall give full publicity, as far as may be practicable, to this provision."

State Boards Improve Terminals

Insofar as the states are concerned, one commonwealth after another has either adopted a state port, or has authorized the expenditure of funds upon state port terminals. The California State Board of Harbor Commissioners was created more than 60 years ago, and the Louisiana State Board was created nearly 30 years ago. San Francisco and New Orleans are cited as successful ports wherever port authorities and port engineers gather and discuss port conditions. In both instances their success was furthered by the fact that the title to the water front property vested in the state, so that it was not necessary to purchase such property upon which to construct facilities. It also happens that they both have belt railway systems intersecting the various trunk lines entering the respective cities and offering access on equal terms to all ships' berths at a single, reasonable switching charge.

San Francisco Controlled by State Board

The water front around the city and county of San Francisco is controlled by the Board of State Harbor Commissioners, three in number, appointed by the governor of the state. The board elects one of its members president and executive officer. The officers and employees under the board, with certain exceptions, are appointed by the state civil service commission, their duties and powers being prescribed by statute in great detail. The officers and employees mentioned in the statute are a secretary, an assistant secretary, an attorney, a chief engineer, an assistant chief engineer, a chief wharfinger, wharfingers, collectors, a draftsman, a superintendent of dredgers, and such men on the dredgers, scows, towboats and fireboats, and in doing urgent repairs, as may be deemed advisable. Certain of the wharfingers and collectors are appointed policemen by the board of police commissioners of the city and county. Of the three commissioners, the president receives a monthly salary of $300, and each of the other two, $250; the secretary, $250; the assistant secretary, $200; the attorney, $200; the chief wharfinger, $250; the wharfingers, $150 each, and the collectors each $125. Strangely enough, this board of state harbor commissioners has nothing to do with the water front of the bay, extensive as it is, outside of the city and county of San Francisco. This is the more remarkable as Oakland directly opposite San Francisco on the eastern shore of the bay, is a large city, flanked by the smaller cities of Berkeley and Alameda, and the railroad connections on that side are more direct and furnish more room for expansion of railroad yards, etc., than is practicable in the city of San Francisco. However, the San Francisco water front is well managed, and the

organization presided over by the state board is considered almost ideal.

New Orleans Board Has Police Power

Several of the railroads terminating at New Orleans have quite extensive terminals, yet such has been the good judgment and the good management of the state body, known as the "Board of Commissioners of the Port of New Orleans" that the public wharves are used largely even by these railroads which possess facilities of their own. The board consists of five members "prominently identified with the commercial or business interests of the Port of New Orleans." The Commissioners are required to elect out of their own number a president, a vice-president, and a secretary. They are authorized to appoint deputy commissioners to perform the duty of harbor masters, wardens and wharfingers, and "from among the deputy commissioners a superintendent." It is also provided that they "shall have and enjoy all the rights, powers and immunities incident to corporations." They are given the general power "to regulate the commerce and traffic of the port and harbor of New Orleans in such manner as may in their judgment be best for its maintenance and development." Certain port and harbor police are provided for, to be appointed by the commissioners, who are also empowered to administer the public wharves and to construct, extend and improve works for port purposes within the limits of the port, including wharves, docks, warehouses, grain elevators, locks, slips, laterals, basins, and other structures and improvements, and to dredge slipways, channels, slips, basins and turning basins in the Mississippi River. Subject to certain conditions, they may, without further legislative enactment, borrow money and issue notes and bonds. To defray the expenses of the terminal facilities which they operate, they are authorized to levy dockage fees based upon gross tonnage, providing that their charges shall conform to their necessary expenditure. They also have the power to expropriate any property, wharves or landings necessary to be expropriated for the benefit of the commerce of the port and harbor of New Orleans, in accordance with the expropriation laws of the state. Furthermore, the board is given the ordinance-making power, and all ordinances which it passes concerning the territory, jurisdiction and control of the port of New Orleans, and the proper conduct thereof, are enforceable by fine and imprisonment in the same manner as the ordinances of the city of New Orleans now are. The board operates through a General Manager, and is organized into 11 departments: Executive and accounting, engineering, dock, cotton warehouse, grain elevator, coal tipple, navigation canal, purchasing, storekeeping, traffic and employment. There were between 1200 and 1300 persons employed in the year 1922.

There are two other administrative bodies exercising certain powers over the port, the public belt railroad commission and the board of levee commissioners of the New Orleans Levee District. The belt railroad commission is a municipal body of 17 members appointed by the Mayor of New Orleans, part of them on nomination by several commercial organizations. The chief administrative officer is a full time secretary-treasurer. This belt line is not only operated on a self-sustaining basis, but contributes $50,000 annually to the inner harbor and navigation canal. The levee commission is charged with protecting the city from floods by the construction of levees.

States Build Piers

There are other states which, through commissions, control ports. Time will not permit a detailed description of the organization of each commission. The port of Portland, Maine, is one of the ports so controlled. Recently a state pier has been constructed. It is said to be doing well.

The division of Waterways and Public Lands of the state of Massachusetts' Department of Public Works is the controlling authority over the development of port facilities and the disposition of the state's water front property. The state has built at Boston some excellent facilities as, for instance, the splendid Commonwealth Pier. Boston is, nevertheless, under present conditions, essentially a railroad port, with each railroad having its own terminal, and with no coordinat-

ing influence over them. Should a shipment miss a steamer at any one of the railroad terminals, it would have to await another steamer at the same terminal or be transported many miles at much switching expense to reach one of the other railroad terminals and another ship.

Rhode Island has a state board of harbor commissioners, and Providence has both a state pier and city wharves.

New London, Conn., has a port administration, vested partly in the city and partly in a state board.

Mobile, Alabama, is a good example of what can be accomplished by having state support. Being the only port of its state, it was a comparatively simple matter to obtain this support. The sum of $10,000,000 has been voted for expenditure at Mobile for proper terminals, to be administered by a body known as the "State Harbor Commission of Alabama," consisting of 7 members, appointed by the governor for a term of five years. The best site in the harbor has been selected, engineers employed, and a tentative layout made for present and future development. Incidentally, a large area has been set aside for railroad yards, an important adjunct to any proper port scheme. The duties of the commission are definitely fixed by law. They are given broad powers, inclusive of those of a common carrier railroad.

Cities Control Some Harbors

On the Atlantic seaboard and the Great Lakes the ports are more frequently controlled by the municipal government. At some ports, such as New York and Philadelphia, the powers and duties of the dock department have been fixed by statute. In others they are fixed by local ordinances. In a few important instances, the administration of the port is not delegated to any single agency, but comes within the partial control of numerous unco-ordinated and overlapping departments and offices.

Chicago Authority Divided

Thus in your city of Chicago no less than five separate governmental agencies or offices have some jurisdiction over the harbor waters. In addition to federal supervision and maintenance of the river channels and canals, the state of Illinois assumes jurisdiction over the same area through the division of waterways, department of public works and buildings. The committee on harbors, wharves and bridges of the city council initiates legislation for the control and improvement of the port by the municipality. The bureau of rivers and harbors, under the harbor master, polices the harbor waters, performs certain engineering functions, and may issue certain wharfing permits with the approval of the commissioner of public works. The commissioner of public works exercises control over private construction work in the harbor through the issuance of permits. Two separate park boards have certain powers to improve the lake front and reclaim submerged lands. Finally, the sanitary district, organized to control the disposition of sewage, has been engaged for years making important improvements in the navigable channels.

Port control at your neighboring city of Milwaukee rests in the common council of the city.

States Co-operate at New York

I have already touched upon the construction of wharves by the city of New York. It should be noted in passing, however, that the adjoining states of New York and New Jersey, recognizing the necessity for the co-ordination of port facilities and port administration, have, after an extensive investigation involving the expenditure of upwards of half a million dollars, appointed a joint New York-New Jersey port authority to look after the future of the port. A comprehensive plan has been adopted. At present, the port authority is devoting the greatest amount of attention to the establishment of a railroad belt line. It recognizes the fact that this is perhaps the greatest single co-ordinating influence they can have.

In 1917, the state of Delaware created a board of harbor commissioners of the City of Wilmington. Three commissioners are appointed by the Mayor. They have already established and placed in operation an excellent terminal.

The state of Maryland has authorized the expenditure, over a period of years, of

$50,000,000 at the port of Baltimore. The state act of 1920 directed the Mayor and city council to provide by ordinance for a commission to administer the fund, no part of which, however, can be expended until provision has been made in each case for a client who will lease the facility over a period of years. The arrangement is thus similar to that existing in the city of New York.

The port of Philadelphia has many excellent modern piers, administered by the city.

Eastern Ports Have Various Plans

At the port of Norfolk, Va., the authority to develop water terminals is conferred upon the city by its charter. Here the administration of the municipal port property is entrusted to a director of the port. Not only has the city recently finished extensive wharfage and a large, modern grain elevator, but it leases a large part of the army base terminal, built during the world war, and is negotiating for the lease of the remainder. Its business administration is very much alive and has a soliciting freight department. An act passed by the General Assembly of the State of Virginia in 1922 established a permanent port commission to investigate the possibilities of greater development of the port of Hampton Roads.

The city of Charleston, S. C., created in 1920 a port utilities commission, which has purchased certain railroad properties, inclusive of a railroad belt line. It also leases and operates part of the army base terminal, constructed during the world war. The city of Charleston and the Charleston Chamber of Commerce employ a foreign trade and port development commissioner.

The city of Savannah, Ga., has ambitions to become the state port, and a movement is on foot to establish such a port. Outline plans have been drawn for a terminal at Savannah, but this city has competitors in other ports of the state which hope to land the designation of state port, with the consequent expenditure of state funds.

Jacksonville and Tampa, Fla., have city terminals and business administrations.

Texas Has Many Ports

The state of Texas has numerous ports and there is no prospect of any one of them being designated as the state port, but the state has furnished assistance in certain cases as, for instance, at Corpus Christi which is now building, with a combination of state, county and city funds, a seaport for the accommodation of ocean commerce. Galveston, the most important port on the Texas coast, is a leading outlet for grain and cotton. It is conspicuous by reason of the absence of any public administrative agency comparable to those already described. Practically all of the terminal facilities are privately owned and are subject to city ordinances, while wharfage, switching, handling and other charges assessed against cargo are filed with the Interstate Commerce Commission and are subject to the jurisdiction of that body. This latter is due to the fact that the Galveston Wharf Company operates a railroad. While the city has no other direct control over the port, it owns one-third of the stock of this company, which is the principal terminal company of the port. The city is represented on its board of nine directors by the Mayor and two of the four city commissioners.

The city of Houston, Texas, lies 50 miles inland from Galveston. In 1912 work was undertaken for the construction of a ship channel for ocean vessels. The city furnished half of the money for the channel, and all of the port facilities, which are administered by a municipal department. Houston has been so successful that it has already been obliged to double its wharfage and sheddage capacity. Its board of five directors serves without compensation. All of these men are prominent in the city's business institutions.

Pacific Ports Are Active

In the states of Oregon and Washington the voters of the county may petition for a port charter in conformity with the general laws relating to ports, and may elect the commissioners of the corporation and exercise a certain control over its major activities.

It may be said that practically all the ports of the Pacific Coast are especially progressive, and Seattle, the principal port of the state of Washington, and Portland, the principal port of Oregon, have both provided most liberally for the accommodation of ships and shipping. The governing bodies are definitely fixed, but time will not permit a detailed statement. Their powers, and indeed those of most of the port bodies already enumerated, are shown with considerable definition in a volume entitled "Shore Control and Port Administration," published by the Board of Engineers for Rivers and Harbors of the War Department, with which I am serving. Those who contemplate port organization will do well to consult this volume.

Los Angeles Extended City to Harbor

A statement with regard to the port of Los Angeles should not be omitted. This city originally lay 20 miles from the Pacific Ocean, but it acquired a narrow strip of land extending to the water front and has established a port district. By virtue of its oil business, the port now boasts the second largest annual tonnage among American ports. Los Angeles is unique in that 200 members of its chamber of commerce have pledged themselves each to give $1,000 in order that the city may have a proper port plan, not only for present business but for expansion in future years. Los Angeles and its neighboring city, Long Beach, recently petitioned the national government for an extension of the breakwater of the harbor, in order to secure more room. The Board of Engineers for Rivers and Harbors, which passed upon this case, suggested to the Chief of Engineers that the project be recommended favorably to Congress with the proviso that the entire community establish a port district, jointly controlled, build a belt line unifying the railroad systems of the port, and furnish half of the cost of the breakwater. The Chief of Engineers has approved this recommendation, but Congress has not yet passed upon it.

Port Management Is a Business

I have endeavored to show both something of the means of providing a port administrative body and an outline of the duties of such bodies. There are many other angles from which the subject might be treated. The fact of the matter is that the management of a port is a real business and requires a business organization. Time will not permit a definite analysis of the many features which must be considered by a port body. The Research Committee of The American Association of Port Authorities has undertaken to prepare a reference book on matters of port organization, port administration, port construction, maintenance, protection, facilities and appliances, handling, efficiency, finance and other particulars for the harbors of the North American Continent. The Chairman of the committee, G. F. Nicholson, Chief Engineer of the Port of Seattle, is a progressive port engineer, who has devoted attention not only to port planning, but to port equipment and port operation. Some of the handling equipment for his port of Seattle has been built from his designs and operated under his general direction. The questionnaire compiled by the Committee covers 18 pages, cap sized paper, with 31 main headings and many questions under each heading. These headings are: General organization of port administration; organization of staff; system of operation; ownership of water front; berthing capacity; storage facilities; type of wharves; type of transit sheds; type of warehouses; mechanical freight handling equipment; rail terminal facilities; roads and highways; auxiliary waterways; oil handling facilities; import and export tonnage; traffic movement in port, inclusive of ship, rail and vehicular; port charges and wharfage; dockage; pilotage; towage; lighterage; switching; cartage; stevedoring; financial; traffic promotion; advertising and industrial sites. I should like to go into some of the details under those various headings, but this is scarcely practicable within reasonable limits of time.

Ports Must Solicit Business

The headings of "traffic promotion" and "advertising" are especially suggestive. Every railroad has its freight soliciting department and cannot do without it. Every live port must expect to

solicit business if it proposes to keep pace with its competitors. If you have occasion to ride on a street car in central freight territory, of which the Chicago district is a part, you are likely to see a car card advertising the port of New Orleans. When you have established connection with the various ports of the United States, you will from day to day receive pamphlets and leaflets, some of them extensively illustrated, descriptive of the facilities and general attractions to business of such ports as Jacksonville, New Orleans, Houston, San Francisco and Seattle. Perhaps the latest of these to come to my own desk is a publication entitled, "The Port of Seattle," which is bound handsomely in brown, with a blue and gold title. Inclusive of advertisements, it has 108 pages. The title page is in colors, as is the relief map of the general region of the sound and straits. There are many pages of photographic illustrations, descriptive of the business of the port, as well as indicative of the handsome and ample accommodations for ships and shipping. There are, also, in the text, descriptions of the public terminals, of the mechanical equipment, of financial conditions, of transportation lines operating out of the port, as well as comparative tables of the business of this and other ports. It would be very interesting to know the cost of this publication. It is made possible, no doubt, by the many advertisements, which detract from the book as a whole no more than do the advertisements in the back of a magazine. From a financial standpoint, I doubt whether any of the many advertisements pay for themselves in a publication which must be limited in circulation, but those advertising are all doing business in the port, and whether they receive a direct return or not they are doing their share in the advertisement of the port. It must be worth while.

Chicago Port Undeveloped

Turning now to a brief statement with regard to Chicago's own problem. It has been my duty within the past few years to make several reports upon various phases of the Chicago situation, so that I feel that I know something about it. Chicago, without a doubt, owes much to its position at the foot of Lake Michigan. Yet it has not devoted that atention to waterborne business which its position would seem to justify. I take it that the members of the Western Society of Engineers desire to further Chicago's interests. Between the trunk line railroads entering the city and its various parks, Chicago has not left much on the lake front for water terminal development. However, with proper breakwater construction there should be no difficulty in constructing the necessary terminal facilities. All of that portion of water-to-rail and rail-to-water tonnage which may be looked upon as through business should be shunted around the heart of the city. The terminal for this purpose should be in the neighborhood of South Chicago at some such location as that chosen by the late Colonel Judson, and which he christened "Illiana." There should be terminals in District No. 3 for the transshipment of that part of the freight which comes to the so-called loop district for manipulation for manufacture, or which originates there for outward shipment. A great deal of this business will move by trucks, but rail facilities must be provided also.

I had occasion several years ago to pass upon a proposed industrial development for the Lake Calumet region. There is no reason why an extensive industrial development at this point should not take place, provided always that reservation is left on the water front for the necessary terminals for transit business. For the three localities named, plans should be made which will allow expansion for many years to come. I hope that your society will be prominent in this movement for the proper development of the port of Chicago, and that in its efforts it will not lose sight of the fact that first there must be organization, then there must be a proper commercial survey in order that Chicago may know what kind of goods it is likely to handle and how much of each kind, together with the shape and size of the packages in which it will be handled. With such information at hand, the port engineer will be able to devise the proper layout and the proper equipment. The correct juxta-

position of the rail carrier and the water carrier is an important feature to be borne in mind, and this in turn presupposes that there will be ample sheddage area in which to handle, assort and mark package goods, and an ample railroad yard area for train make-up and break-up, and for car storage.

May I say in closing that the Board of Engineers for Rivers and Harbors of the War Department, with which I am serving, is charged with the business of advice to ports. In order that we may advise ports, it is necessary for us to have the proper information. We have been collecting this information and publishing a group of volumes known as the Port Series, descriptive not only of the physical aspects of the principal ports of the United States, but also giving a picture of the traffic of each port, including something of origin and destination of export and import traffic.

We have been advising many ports on the coasts of the United States and on the inland waterways. This work centers in Washington, where we have an organization for the purpose. Some of the division and district engineers have taken a very live interest in the development of the water front of the ports where they are stationed. The late Colonel Judson was particularly active in this respect, and his ideas were eminently sound. Major Putnam has taken up the work where he left it, and has been so thorough in his treatment of the subject of terminals that I can readily understand why he desired me to treat of port administration only.

DISCUSSION

E. J. Noonan, M. W. S. E.: It has been my good fortune during the past ten years to be identified with the railroad terminal developments in Chicago, and there never has been a time during those ten years that we have lost sight of the fact that the railroad terminals should be co-ordinated with the water terminals. In 1914 the Railway Terminal Commission made a trip to Europe and collected a vast amount of information on Port Administration and Port Development, and we have a very complete file on that subject.

When the Illinois Central Lake Front Ordinance was up for consideration, the War Department indicated at that time that the plan would not meet with its approval unless adequate provision was made for water terminals. I think that the ordinance as passed in 1919 and approved by the War Department, contains all of the provisions, as far as District, Number Three, is concerned, that could be anticipated. The fore-shore of Lake Michigan is shallow for quite a distance out. As far as filling is concerned, there is not very much difference whether that harbor was a half or three-quarters of a mile distant from the existing shore line. The parkway intervenes between the harbor and the railroad tracks. That was one of the first objections and was, in a way, objected to by the War Department, but it was shown that in order to get to the harbor the tracks of the railroad would have to be crossed overhead and that to overcome the height, getting back down to the water level, it did not make much difference whether the harbor was adjacent to the tracks or half a mile away from them, the same distance had to be traveled before reaching the harbor grade. So the intervention of the park does not place the harbor any farther away from the railroad connections.

That ordinance provided for a number of street accesses to the harbor, provides for four lines of railroad connections and obligates the Illinois Central to perform the switching service for all the railroads. We did all the things we could do at that time, but we did not have a Port Authority or recognized plan for Port Development of Chicago.

Robert H. Ford, M. W. S. E.: We are all indebted to Captain Chambers for his excellent paper. There was one point he brought out which is especially appealing to Chicago, viz: that in addition to State and Federal agencies this city has no less than five separate and independent governing bodies with jurisdiction over its harbor waters, as compared with a single centralized authority for port facilities and administration for the States of New York and New Jersey.

Apart from its seriousness in arresting

natural development the absurdity of the situation would impress even the most casual observer, who has viewed alike the vast harbor facilities in and around New York and New Jersey and the existing situation along the Chicago River, lake front and in the Calumet District.

If the popular report be true, that Major Putnam refused approval of the proposed LaSalle Street Bridge across the Chicago River until assured that necessary steps would be taken to adopt a port policy for the city, it is evident that his action is amply justified and he should be thanked by the citizens of Chicago for his sound reasoning, irrespective of the temporary disadvantage to the City and the furore raised in the papers as a result of with-holding this authority.

Captain Chambers in his paper has furnished an excellent background for working out a port policy for Chicago, and while it is probable that this is all he was attempting to do, nevertheless it seems unfortunate at this time that he could not have enlarged to a greater extent on the subject of lake ports for inland cities, as I notice his paper dwells largely on seaboard cities and terminals. Probably this is due to a feeling in his mind that in reality there is little or no difference between coast-wise shipping and inland waterway traffic, which is not the case, irrespective of the claims put forth by its supporters.

Unfortunately for the country, those citizens who spend their lives on problems of transportation as a practical business matter and are well informed thereon, are usually considered to be biased and unfriendly to inland waterways, especially if they raise their voices in an effort to point out the economic weakness and inconsistency of such projects. There is absolutely no need for the development of our inland waterways, and however we may feel about it sentimentally, they have long ceased to be a factor, as a result of the great advances which have been made in the science of transportation.

Railroads today have their own troubles, and are fighting for their very existence, and there is a very compelling desire on the part of most railroad men to avoid anything that may be construed as antagonism to such public projects.

My comments on this matter are not made as a railroad man, but rather as an engineer who has had special advantages for observing transportation in some of its broader aspects.

Largely on account of the opportunities presented, and not because of its worth, deep waterways—inland waterways propositions have attracted many people who for convenience may be divided into;

(1) Professional politicians. On account of the type and character of the work and the vast expenditure of public funds, inland waterways offer an especially attractive field both with respect to individual and collective opportunities for advancing political fortunes.

(2) The honest, but ignorant man, long on a few facts, but exceedingly short on their economic application, or their relation to other equally important facts, which he has neither the training nor experience to properly examine.

(3) The average man. He constitutes the vast majority who know absolutely nothing about the matter, but are easily impressed with any kind of development that is apparently to be paid for by someone else, especially when fed up on alluring and absurd statements by a waterway advocate.

The urge to develop inland waterways reminds me of the man who is continually leaving one job uncompleted, starting something else to take its place. It is like a half dozen churches in a small community where the ministers and their families are required to live on less income than is obtained by an itinerant laborer. If they would find some means to combine their efforts, one strong, healthy organization properly supported would not only suffice, but do much better work, and accomplish the individual and collective purpose desired by all. The waterways and railways are a case in point.

There is a popular fallacy that the railroads are broken down and really inadequate to supply transportation for the

present and future necessities of the country on an economical basis. This is erroneous. The railroads are the basic transportation agency of the country, the very life-blood of the nation, and every other form of transportation is directly dependent upon them, and the prosperity of the country as well as of each individual is bound up in their successful performance. This is fundamental and ought to be kept in mind by every citizen, especially by the engineers.

Unfortunately, as I sometimes think, transportation is a science which requires a well-balanced economic knowledge of every other form of basic industry. It is for this reason possibly, that some of our legislators and others take adverse action which has such a far-reaching effect on its proper development, but which it is difficult to present.

The American railway system is no longer privately owned, and in the sense that the term is popularly understood. It belongs to more than 2,000,000 of our citizens exclusive of a vast additional number who are indirect owners through investments of their savings therein by estates, insurance companies, banks and similar concerns. Nearly $24,000,000,000 is now invested in the American railway enterprise.

If but a fractional part of the money necessary for the development of inland waterways (irrespective of the vast annual expenditures for maintenance thereafter) could be spent on the railroads to complete their development along lines of modern demands, they could handle more cheaply and with greater dispatch than is now possible, all the business which this country can or will produce for many, many years to come. This statement is based upon the best estimates which our accountants familiar with the resources of this country have been able to develop, but to accomplish this, they must reduce grades, double track their main traffic thoroughfares, and secure terminal facilities designed along modern lines, which cannot come until ample funds are provided through improved railway credits.

When there is less talk about inland waterways and more action toward obtaining satisfactory railway credits with all that implies, there will be no complaint about railway rates. There are very great possibilities in the direction of improvements which will directly react on reducing transportation costs, a fact which should also be kept in mind by advocates of other forms of competitive transportation, if they expect to make it remunerative from the standpoint of investment.

Other things being equal, traffic naturally seeks the avenues of lowest cost and the railways being standard transportation routes and highly competitive, they can be depended upon to reduce rates as fast as modern development enables them to do so. When our citizens fully realize this, they will insist on legislation that will permit the necessary funds to flow to the transportation agencies for their development on such lines.

There are few railroads today which could not spend large sums on their properties in such a way as to net not less than 20 and even as high as 50, and in places 100% on the investment, and such expenditures will inevitably react in lowered transportation rates.

Compare this with the subsidized Federal and State waterways which depend on the tax-payer's money not only for construction but for maintenance, and yet further for assistance in the cost of operation. It is ridiculous if it were not serious to think that public funds should be thus dissipated, and engineers who are trained to look at such matters dispassionately and deal with facts should aid in such matters, rather than be a party to the dissipation of public funds through obsolete and impractical forms of transportation.

Captain Chambers also stated that Chicago's position (presumably in the industrial world) is due to the fact that it is at the foot of Lake Michigan and also that it (Chicago) has not devoted the attention to water-borne business which its position would seem to justify.

This statement might have been correct for the Village of Chicago of 50 or 75 years ago, when railways served as an auxiliary to the canals, but it is not so for the Chicago of today. Chicago owes its position as one of the greatest indus-

trial centers of the world to its unrivalled railroad facilities.

Captain Chambers has also referred to the construction of additional terminal facilities in the vicinity of South Chicago for the transportation of freight which comes to the loop district for manipulation, manufacture, etc.

There are at present ample railway facilities in the shape of dock houses and wharves in the South Chicago District, which are rotting down because they are not used. One railroad in particular has elaborate facilities which have not been used for years for lack of sufficient business.

The changing methods and a better understanding on the part of shippers in packing and distribution has resulted in reducing greatly the requirements of this character. Furthermore, the business to the central district has been dwindling for a long time, due to economic changes whereby the loop is becoming more of an administrative rather than manufacturing district area, and this with improved methods in distribution and assembling carload business direct at points manufactured has resulted in great changes over what formerly existed, and there are also great possibilities for the future, all of which tend to further out-distance methods necessarily employed by inland water transportation.

TECHNICAL PAPERS

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A Survey of Current Progress in Radio Engineering

By Dr. J. H. Dellinger*

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There is no need for more sensitive radio receiving sets than we now have available according to the author of this paper. Use of higher frequencies or shorter wave lengths offers possibilities of greater use of radio, longer range and less interference. Directive transmission is becoming perfected to a high degree which taken with automatic relaying may result in an entirely new communication system. Closer regulation of stations has reduced much of the interference. This is the day of radio engineering or perfection rather than pioneering of inventions.—Editor.

A SURVEY of progress in radio reveals that this is the era of radio engineering. This statement does not refer to the importance or extent of radio engineering but to the type of development now going on in radio as compared with that of past years. Relatively speaking, radio has been crude heretofore, whereas the progress now being made is not merely empirical but is more largely characterized by actual engineering development. We now have not so much the invention of devices as the perfection of them. This statement is very general. There have, of course, been triumphs of engineering in the past history of radio, and on the other hand the process of "cut and try" will continue to be used in the future. Nevertheless, broadly speaking, radio engineering has now taken definite form and is the tool by which further progress in radio will be wrought.

While a number of outstanding recent developments arrest the attention, it is also true that very substantial progress is being made all along the line of radio engineering. Thus, in the development of new and improved radio communication methods or systems, we have marked extension of the available frequency range, great improvements in directive radio transmission, advances in the perfection of selective radio systems, and engineering development of line-radio or carrier-current communication. Among radio devices and applications of radio there is outstanding progress on radio beacons, on the uses of radio for aircraft navigation, on direction finders, and on radio vision. In the field of research and study of the problems of radio, we have important progress now going on in radio measurements, in standardization of apparatus, in the study and mitigation of the vagaries of wave propagation and atmospheric disturbances, and in the wide reaches of the interference problem.

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Limits of Reception Reached

We have now progressed from Marconi and the coherer in 1896, through the invention of the electron tube by DeForest in 1906, past the development of amplifiers by the French and other engineers in 1914, and have found a way to fit into the scheme of radio the great development of broadcasting which began in 1920. While the public acclaim of broadcasting continues and there is still wonderful progress ahead in broadcasting, the obsession of broadcasting has perhaps begun to subside and radio engineering is no longer monopolized and obscured by it.

Little will be said about broadcast receiving circuits in this discussion. A very large part of the more popular literature on radio is devoted to this one subject. While many interesting and valuable things in this field are constantly appearing, there has been very little basically new in radio receiving apparatus in many years. It is also coming to be realized that it is not worth while to increase the sensitivity of receiving sets further. The slight electrical discharges always going on in the atmosphere cause a certain background of noise in a radio receiving set, and these discharges can probably never be prevented any more than variations of weather can be prevented. They are thus a sort of natural limit to what a receiving set can do, for if the waves from a distant station are weaker than the average of these atmospheric disturbances, no increase of amplification in the receiving set can bring in the distant station without the interference. It is therefore not the sensitivity of receiving sets which gives the real limit to the distance of reception, but rather the general level of intensity of the background of atmospheric and electrical disturbances. All of the vast engineering and amateur effort to make more sensitive sets can henceforth be considered as being spent for the benefit of those radio listeners who desire to hear distant stations, with interruptions, rather than for the listeners who desire to hear only the radio programs that come through without extraneous disturbance.

High Frequencies

The most conspicuous recent development in radio engineering is the conquest of the new domain of ultra-radio or very high frequencies (short waves). Even the existence of the vast range of frequencies above 2000 kilocycles (below 150 meters) was hardly suspected, and certainly was generally forgotten, up until less than a year ago. One curious reason for the subordination of this range of frequencies has been the erroneous use of wave length in meters as an expression of radio frequencies. Radio engineering actually deals with currents which have a certain frequency. The wave length of the wave as it travels along in space can be calculated from the frequency, but it is a derived and an artificial concept. It is unfortunate that it was introduced in the early history of radio and came to be used more extensively than the concept of frequency. The usual unit of frequency used in radio is the kilocycle (1,000 cycles per second). Frequency in kilocycles is equal to 300,000 divided by wave length in meters, and, vice versa, wave length in meters is 300,000 divided by frequency in kilocycles. Between 150 and 0 meters, there seems to be only a small territory, but expressing the same fact in terms of kilocycles it at once appears that there is an infinite territory above 2,000 kilocycles.

At the Second National Radio Conference held in March, 1923, the frequencies above 2,000 kilocycles were entirely neglected since no radio communication to speak of was carried on above that limit. Now, however, frequencies up to 20,000 kilocycles have come into extensive use. By their aid speech has been transmitted to the antipodes on 3,300 kilocycles; we may say that a demonstration has been given of the ultimate goal of radio. Actual radio services are being conducted in this region by broadcasters, transoceanic communication companies, military services, amateurs; in short, every important radio interest has begun operations between 2,000 and 20,000 kilocycles. Even higher frequencies have been used

in experiments, but there is every likelihood that in the development of frequencies above 20,000 kilocycles directive transmission will predominate and the problems will be of a distinctly different character.

Expands Range of Operation

In the exploitation of the high frequencies the radio world finds itself in the position of a person who has fallen heir to a rich legacy, for there is now available for actual use a region roughly twice as great as radio had at its disposal a year ago. Calculated on the basis of channels 10 kilocycles wide the gain appears far greater than this, since between 2000 and 20,000 kilocycles there are 1800 such channels, as compared with only 200 such channels in the older region below 2,000 kilocycles. It will, however, probably be a long time before full advantage can be taken of the channels thus theoretically available. Assuming that at present, receiving sets can satisfactorily receive stations situated at equal distances having a frequency separation of 2%, there are only 116 channels immediately available as against the 1,800 channels theoretically and eventually available.

So important are these high frequencies now, the Third National Radio Conference, held in October, 1924, parcelled out the high-frequency territory among the various radio services, thus reaching a solution of a problem which only a year ago was regarded as insoluble, that of finding more communication channels. Alternate frequency bands approximately 10% wide were assigned to the following different services: land point-to-point, aircraft, ship, relay broadcasting, public service, amateur and army mobile. An important principle was followed in this assignment, viz, each service was protected from possible harmonic interference from stations of other services by placing the several frequency bands of any given service on its own harmonics.

Short Waves Travel Farther

What are the reasons underlying this revolution in the use of the higher frequencies? One reason is that the waves of very high frequency behave differently and carry to much greater distances than the behavior of the lower frequency waves would lead us to expect. To understand this better it is necessary to consider the law of radio wave transmission. The principal facts are expressed by the formula

$$H=\frac{I\,f}{d}$$

where H is a quantity proportional to the field intensity of the radio wave. I is the transmitting antenna current, f the frequency and d the distance. According to this it would be expected that a more intense field, a stronger wave, would be produced at a given distance the higher the frequency; in other words, that high frequencies would be better than low frequencies. However, it was found in the early days of radio that this formula does not represent all the facts. As a radio wave travels on, part of its power is absorbed by the earth or other obstacles, and in order to take account of this absorption it is necessary to divide the right-hand member of the above formula by the factor k $\sqrt{f\,d}$. The higher the frequency the greater does this absorption factor become and the smaller the received wave intensity. Moreover, since the frequency enters as an exponential, the absorption becomes extremely great for high frequencies and long distances. It has therefore come to be accepted in radio engineering that for long distance communication it is necessary to use the low frequencies, and the commercial transoceanic stations in fact use the very lowest radio frequencies or longest waves. All this has represented the facts very well for daytime transmission.

For night-time transmission, however, the matter is more complicated, and becomes very interesting. When using frequencies of the order of 1,000 to 2,000 kilocycles, it has been very commonly observed that the waves carried much greater distances at night but in an irregular way, being accompanied by fading. It appeared that some influence was at work at night which caused the transmission distance to vary from in-

stant to instant, between the distance that would be calculated on the basis of the usual absorption factor and a limit determined by complete disappearance of the absorption factor. Recent work with the still higher frequencies, above 2,000 kilocycles (below 150 meters), indicates that at these frequencies the absorption factor is still more likely to be absent or not effective. In other words, at the very high frequencies the real superiority that would be expected from high frequencies on the basis of the simple formula first stated above is actually realized, and the absorption phenomena which limit the distance of transmission at the lower frequencies are non-existent or less in magnitude.

Explains Irregular Transmission

An explanation of these peculiarities of wave transmission at various frequencies may be given as follows: There is in the upper atmosphere at a height which has been roughly estimated at about 60 miles, a level at which the very rare atmosphere is practically all ionized, and above which it can be considered as a permanent conductor. The phenomenon of aurora has its seat above this level. This level is called the Heaviside surface or the Kennelly-Heaviside surface. In the daytime the air between this surface and the earth is heavily ionized by the sun's rays, and radio waves can not penetrate very high into it. The waves travel in the daytime, therefore, along the ground, and are subject to absorption by the more or less imperfect conducting objects and materials along which they travel. As previously explained, this absorbing effect is greater for the higher frequencies and therefore in order to cover great distances the lower frequency waves must be used. At night, however, the waves are free to traverse the upper air and reach the Heaviside surface and travel along it. The higher frequency waves reach great distances because they are not subject to the absorption experienced at the surface of the earth, and therefore actually have the advantage which theoretically the high frequencies should have. The transmitted waves, however, are subject to more or less variation because the Heaviside surface is presumably not strictly smooth but is rough or wavy and has large shifting masses of more or less ionized air in and near it. These variations account for fading. If the dimensions of the irregularities or masses at or near the Heaviside surface be assumed to be in the neighborhood of 200 meters, they would produce no effect on the longer waves but would irregularly absorb the waves around 200 meters and cause variations in received signal strengths.

To explain the behavior of the waves shorter than this, it may be assumed that these shorter waves find their way in and out among the obstacles and masses associated with the Heaviside surface and are not broken up by them in the way that the waves around 200 meters are. It would therefore be expected that these very short waves would be subject to less fading and go greater distances, and this is found to be the case. There is some evidence that these very short waves travel better in the daytime than do the somewhat longer waves. This can only mean that they find the way somehow without much absorption in the space between the earth's surface and the more heavily ionized upper parts of the atmosphere. It must not be thought that they travel as well by day as by night; it has in fact been found that for a long path of travel the absorption is proportional to the average altitude of the sun over the whole path. This whole explanation involving the upper atmosphere is, of course, only a hypothesis, and other explanations based entirely on electrical conditions at or near the earth's surface are conceivable and have been advanced.

Higher Efficiency at Station

In addition to the great distances of transmission, an advantage of the higher frequencies is that the transmitting antenna and station operate at high efficiency. With a relatively short vertical antenna it is easy to have a radia-

tion resistance which is the greater part of the total resistance, a condition which is very far from true with lower frequencies. This means that the greater part of the power fed into the antenna is actually radiated instead of lost in heat. The apparatus for a short-wave transmitting station is relatively simple and cheap. The antenna coils and other parts are smaller and work at lower frequencies. Another great advantage is that atmospheric disturbances are very much less noticeable than in lower frequency transmission.

The disadvantages of the high frequencies are few. One of these is that automobile ignition systems emit waves of the order of 10,000 kilocycles and higher frequencies, thus giving a troublesome source of interference. Another disadvantage is that the waves are so short that many objects about a building or laboratory have natural frequencies in the range used, and it is difficult to make measurements and be sure that spurious effects are not introduced by radiation or absorption of power from such objects. Even measuring instruments and their component parts have such natural frequencies and introduce errors which must be carefully guarded against. Similarly in short-wave transmitting apparatus the generators used to supply direct current and other devices may readily produce a high frequency which is troublesome because it may carry with it a low-frequency modulation due to a commutator or other source which may introduce a ripple in the transmitted signal. It has been suggested to the author that there may be resonances affecting short-wave transmission even from the sands on the seashore, inasmuch as ordinary sand has the property of piezoelectricity, and that this may have an influence in fading and dead spots. Piezoelectricity is an important property, applications of which will be mentioned later. Suffice it to say here that there doubtless is an actual response to radio waves of a very high frequency by every grain of silica sand.

Directive Transmission

Great progress is being made just now in perfecting methods of confining radio transmission to a desired direction. The methods used go back in principle to the first suggestion which was made along this line. This original plan contemplated the use of two vertical antennas ½ wave length apart with currents in opposite direction, that is 180° different in phase, in the two antennas. The phase difference of 180° between the radiation from the two is just compensated by the half wave length of distance between them, as far as radiation along the line joining them is concerned. Along this line, therefore, their effects add together. On the other hand, for a point on a line at right angles to the line joining them, there is no such difference of distance and the radiation from one exactly neutralizes that from the other.

More actual use has been made of another method of directive transmission which is apparently very different but is in a sense the same in principle, namely, the loop or coil antenna. If a large loop antenna is used as a transmitting antenna, on account of the fact that the current is in opposite directions in the two vertical sides there is theoretically no transmission in a direction at right angles to the plane of the loop antenna and a certain maximum of transmission in a direction in the plane of the antenna. Since the distance between the two vertical sides is usually considerably less than a half wave length, such an antenna is not a powerful transmitter. Its value as a directive transmitter is furthermore limited because the capacity of the whole structure to ground acts as an ordinary nondirective antenna.

A third method which has come into use is applicable only to very high frequencies or short waves. It involves the use of a parabolic reflector placed behind the vertical transmitting antenna. The method is only practical when the wave length is so short that a reflecting structure is not unwieldy. In order to be effective the reflector must be an appreciable part of a wave length. None of these methods give anything approaching a strictly narrow beam of

transmission analogous to a searchlight used for projecting a light beam. They merely give a transmission in one direction which may be several times the intensity of transmission at right angles to that direction.

Uses Multiple Antennas

A fourth method is now being developed by Marconi in England and by American companies, which seems to offer much greater promise. It is an extension of the original scheme for directive transmission. It is essentially the use of a large number of transmitting antennas and carefully regulating the phases of the currents in them, to give any desired directive effect. One form of this method, commonly called the beam system, uses a straight row of vertical antennas placed close to one another. By means of special generating apparatus, current of identical magnitude and phase is supplied to each of these antennas. Such a system transmits more in a direction perpendicular to the line of antennas than along the line. This may be seen as follows: Suppose the line is one wave length long. Then radiation from two antennas A and A^1 spaced a half wave length apart will give zero effect in the line of the row of antennas, because such radiation from the two antennas A and A^1 would be 180° different in phase because of the half wave length separation between them. At a point perpendicular to this line, however, the distance from the two antennas would be equal and the effects would be additive. For every antenna in the row there is another one separated from it by a distance of one-half wave length. If the row is made several wave lengths long, the sharpness of the beam of waves transmitted becomes very great, that is, there is a large ratio of power transmitted in the desired direction to that at right angles. This ratio may be several hundred. It is theoretically applicable to any frequency but is, of course, most convenient when the wave length is sufficiently short so that the row of antennas does not have to be inordinately long.

Has Undirectional Effect

This system is further improved by placing parallel to the row of antennas a similar row ¼ wave length away. Identical current is fed to all of these antennas at a difference in phase of 90° from that in the first row. For transmission in one direction the 90° phase difference will be neutralized by the ¼ wave length separation, and the radiations of the two systems will be additive, while in the opposite direction the two will cancel each other and thus the system is made strictly unidirective rather than bidirective, sending out something approaching a true beam in a single direction. The same type of system may also be used for receiving, effecting a great gain at the receiving end also. The British Marconi Company carries on commercial communication between Poldhu and Buenos Aires, a distance of 5,800 miles, with this system.

In general, directive transmission is accomplished by using a number of transmitting antennas and so adjusting the phases of the current in each, in relation to their distances apart, that reenforcement of radiation is obtained in one direction and more or less neutralization of radiation in other directions. An obvious advantage of beam transmission is that much lower power is required than in ordinary radio transmission, since the transmitting power is all utilized in sending the waves in the desired direction instead of all directions. This important advantage, which means reduced cost, will probably not be fully realized because the great ratio of transmission in the desired to undesired directions is probably reduced as the wave spreads out to great distances. The undoubtedly great directivity for relatively short distances from the transmitting station, however, offers highly important advantages in another particular, the reduction of interference caused by the transmitting station.

Automatic Radio Relaying

A radically different development which can be considered as, in a sense, a method of directive radio transmission,

is automatic radio relaying. For several years there has gradually developed a method of automatic relaying of radio telegraphy and telephony, the incoming signal being used to operate a transmitting set on a different frequency. Methods are now available to do this on the same frequency. There are various methods by which this is possible; one is a sort of barrage reception, the antenna arrangements being such that the antenna which does the receiving is protected against the radiation from the antenna which does the transmitting. By using any one of a number of such automatic relaying stations it is possible to send a radio transmission along the line of such relay stations and arrive at a distant point with far greater signal intensity than at equal distances in other directions from the original transmitting station. Such a system is actually being used as one method of relaying broadcast programs from one broadcasting station to another. The method is like a long-distance telephone line with its amplifier or booster stations but with the wire line eliminated. Quite possibly such a method will be used in conjunction with the beam system of transmission, thus giving an extremely economical and non-interfering system.

Selective Radio Systems

One of the principal means of overcoming interference between the transmissions from simultaneously operating radio stations is obviously the increase of selectivity or narrowing of the band of frequency which each station uses. Progress in this direction is being made in all the various types of transmission, as for example, through the use of filtering devices for radio telephony and coupled circuits in spark apparatus. The principal advance, however, is the increasing adoption of continuous-wave transmission for radio telegraphy. In continuous-wave, that is, unmodulated transmission, the wave sent out need depart from a pure sine wave only through the variations imposed by the keying, that is, the production of dots and dashes. Even for very high-speed keying this departure from the sine wave and broadening of the wave is very slight. So far as radio telegraphy is concerned, continuous waves furnish a very satisfactory means of securing selectivity at the transmitting end. This makes it possible or worth while to use highly selective apparatus at the receiving end. In order to take full advantage of this system it is necessary that the frequency of transmission be kept quite constant, and where a great many communications must be carried on simultaneously it is also necessary that these frequencies be set accurately to a predetermined value.

Constant Frequency Systems

We thus have the advent of strictly constant frequency systems. A striking means of accomplishing this is furnished by the piezo-electric oscillator. Certain crystal substances, such as quartz, have the property of piezo-electricity, that is, when a piece of the substance is mechanically strained a voltage is produced between its ends, and vice versa, when a voltage is impressed a slight deformation of the body takes place. It follows that when a piece of piezo-electric crystal is caused to vibrate there is produced between its ends an alternating voltage, and vice versa, impressing an alternating voltage upon such crystal causes it to vibrate mechanically. Maximum vibration is obtained when this alternating current has the same frequency as the natural frequency of mechanical vibration of the crystal. By associating such a crystal with an electron tube, it is possible to generate current whose frequency is determined solely by the frequency of mechanical vibration of a crystal. The frequencies thus produced are, happily, in the radio range. Current thus produced by the piezoelectric oscillator can be amplified and supplied to a transmitting antenna. At the receiving end, apparatus must be used to insure response at exactly the right frequency, and here enters the question of frequency standards. This question, and the usefulness of piezoelectric crystals therein, will be mentioned again. A new

radio communication system of the utmost selectivity and precision is made available by this new device, and services which require the operation of a large number of transmitting stations spaced as closely together as possible in frequency and taking full advantage of C W transmission will find this a great improvement.

Interference Problems

There is increasing progress in knowledge of the factors entering into radio interference and methods of eliminating various types of interference. As it affects broadcasting, some information of this kind is available as a result of a program of observations carried on by the Bureau of Standards during the past two years with the co-operation of about 200 voluntary observers, located from 0 to 400 miles from two selected broadcasting stations. Preliminary results show the following averages for all observers; first, no interference, 23% of the times when reception was attempted; interference from other broadcast stations, 32%; atmospheric disturbances, 18%; fading (i. e.,) irregular variation of intensity of received signals, 13%; amateur transmitting stations, 6%; radiating receiving sets, 5%; commercial radio telegraph stations, 2%; non-radio electrical interference, 1%. More complete and final results will show decreases in the percentages for the several causes of interference which are under the control of man, and corresponding increases in the percentages for the natural interference from atmospheric disturbances and fading. The man-made interference of the various types is of local character, some types of it being confined to very small areas around the source of disturbance.

Considering the least of these causes of interference first, steady diminution of non-radio electrical interference is in progress. There are, it is true, frequent complaints of disturbances from a large variety of electrical causes, including 60-cycle power line induction, sparking commutators, X-ray apparatus, arc lights, faulty insulators, electrical precipitators, and many electrical devices used in homes and in industry. Some of these cases involve faulty operation of the electrical devices, and much valuable work has been done by the electric power companies and others through the use of portable receiving sets, direction finders, etc., in tracing down the cause of the disturbance. It should be pointed out, however, that there are some electrical devices which even when in perfect working order cause interference with radio reception. In many cases it is possible to provide shields, shunting condensers, chokes or filters at the source of interference or at the receiving set which relieve the difficulty. There remains a part of such interference, however, which is practically inevitable and which must be regarded like atmospheric disturbances as part of the inherent limitation of radio reception. As previously pointed out, the omnipresent background of slight electrical disturbances which drown out signals below a certain intensity cannot be overcome by increasing the sensitivity of radio receiving apparatus, and sets a definite limit on the possibility of satisfactory reception from far distant stations.

Limit Use of Radiating Sets

Interference from radiating receiving sets is being reduced as a result of a number of influences. As a matter of fact the winter of two years ago when all broadcasting stations were on the same frequency is included in the time covered for the figure above given of 5% of the total interference. The prevalence of such interference was unquestionably greatly reduced by the placing of broadcasting stations on separate frequencies. The recent trend of manufacture and sales of radio apparatus have been to limit use of radiating sets to rural districts. This effort is being supplemented by a campaign of education in the operation of regenerative and superheterodyne sets. As a result, interference of this type is now largely confined to congested city districts, particularly in apartments and row houses, in the reception of distant stations. There is relatively little

interference from this cause with reception from local stations. Technical development of receiving sets will doubtless continue to reduce this type of annoyance.

Frequency Bands Allocated

Interference from radio telegraphy as distinct from radio telephony is decreasing. This includes amateur and commercial station intereference. The improvement is coming about through the keeping of each service more definitely within distinct frequency bands, through closer adjustment of individual station frequencies, and through apparatus improvements, such as coupled circuits, which sharpen the wave emitted. There are three radically different categories of successively decreasing width of wave (formerly expressed in terms of decrement), viz., damped waves, phone, and continuous waves. It is increasingly recognized that the interference produced by damped waves is out of all proportion to the requirements of modern radio communication. Spark transmitting apparatus has been largely eliminated except for ship use. When it is finally eliminated on ships as well as elsewhere, radio will enter on a new stage of perfection.

Since the principal interference to broadcast reception comes from other broadcasting stations, an improvement in this situation is of first importance. Several developments indicate that this improvement is at hand. One thing that should help is the increase of the frequency band for broadcasting provided by the Third National Radio Conference (63 independent channels for the higher class stations as against 39 heretofore). Another trend that is helping to solve the problem of broadcast station interference is the increasing realization that the local stations give better quality and more satisfactory service than the distant stations. While the thrill of reception from very great distances continues, there is a constantly growing demand for reliability and perfection of quality in the received programs which is not obtainable from the distant stations.

Use More Power

The reason why the local stations give technically superior quality and satisfactory reception is simply because they deliver a radio wave to the receiving antenna of an intensity greater than that of the prevailing atmospheric and electrical disturbances. In order to deliver a signal of the same intensity to a larger number of people or a larger territory it is necessary to use higher power in the transmitting station. Hence there will be increases in the power of many of the stations from now on. Considerable fear has been expressed that the use of high power, while of obvious benefit to the farmers and others remote from the stations, would make it harder for city dwellers to tune out the nearest station when they wished to receive others. This fear will not be realized at all if the simple rule adopted by the Conference is followed, of locating stations of higher and higher power farther and farther away from centers of population; in fact, reception conditions will be better for the city dwellers than in the present situation which has the principal stations located in the very midst of the cities.

The past year has witnessed notable progress in the keeping of transmitting stations on their assigned frequencies. In particular, the assignment of separate frequencies to broadcasting stations at the end of 1923 assumed a precision of frequency regulation of the individual stations greatly in excess of the precision previously attained anywhere. The frequency separation of 10 kilocycles between broadcasting stations meant as close as 1% separation and in order that each station operate in its own channel an accuracy of frequency adjustment very much better than 1% was necessary. Prior to 1924, not only did stations in general depart many per cent from their assigned frequencies, but even the wavemeters used as standards for frequency measurement and control by various laboratories and authorities throughout the country, likewise differed among one themselves by a good many per cent.

Establish Frequency Standards

Improvements in the accuracy of frequency measurement were necessary in order to carry out the definite and precise station frequency assignments in all the various classes of radio service. This has necessitated intensive study, particularly by the Bureau of Standards, in the improvement of the accuracy of frequency measurements and standards. This work has included the improvement of standards, the increase of constancy and precision of wavemeters, improved methods of absolute frequency measurement, and the adaptation of piezoelectric resonators and oscillators as frequency standards. The work on frequency standards is so promising that there is now foreshadowed radio operation on frequencies so constant that variations of phase rather than intensity or frequency of the current will produce signals. A new tool, phase variation, will thus be in the hands of radio engineers, with the possibility of important applications to secret, directive, and high-speed signalling.

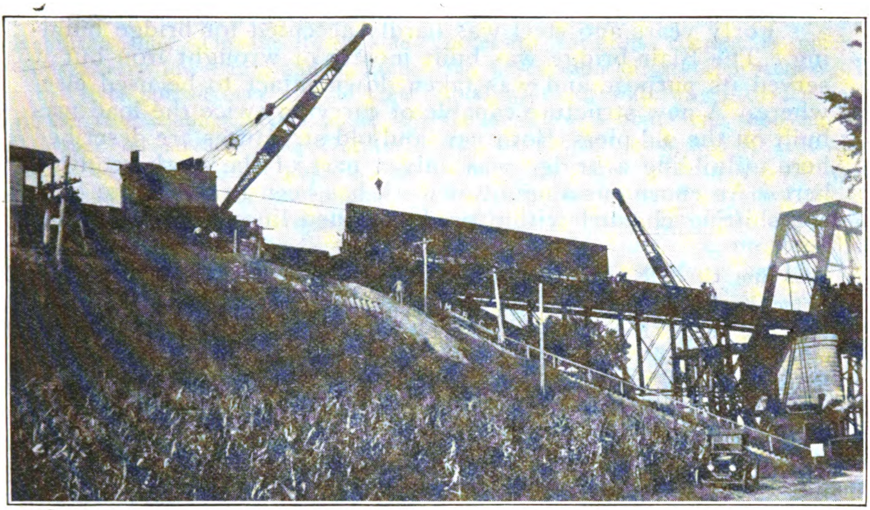
The improved frequency standards are made freely available through the transmission of special radio signals of standard frequency from 125 to 6000 kilocycles. These are transmitted from Washington, D. C., and from Stanford University, California, once every two weeks. Similar signals of standard frequency are transmitted in France and England. As an aid in the mantenance of constant station frequencies, many of the broadcasting stations are using specially constructed wavemeters known as frequency indicators or one-point wavemeters. The importance of using a device of this kind to assist in maintaining the frequency constant is emphasized by complaints which are received by the Department from time to time of interference between various broadcasting stations. For example, a listener in Baltimore recently reported interference between two broadcasting stations, one of which was located in Cincinnati, and one in California, this interference arising because one of these stations was off its assigned frequency by only ½%. Obviously, frequencies must be maintained to a higher accuracy than this in order to make such interference impossible.

The constancy of frequency of some stations is so good that it is possible for the Bureau of Standards to publish each month a list of stations which have been found by measurement to maintain high constancy. The transmissions from these stations thus become available to the public as frequency standards. Since the stations are in operation every day they are particularly valuable and freely available standards of frequency. The experience of the past year on this subject of frequency control proves that proper frequency assignment, supplemented in practice by the actual operation of stations very closely on the assigned frequencies, is a most important element in the reduction of interference.

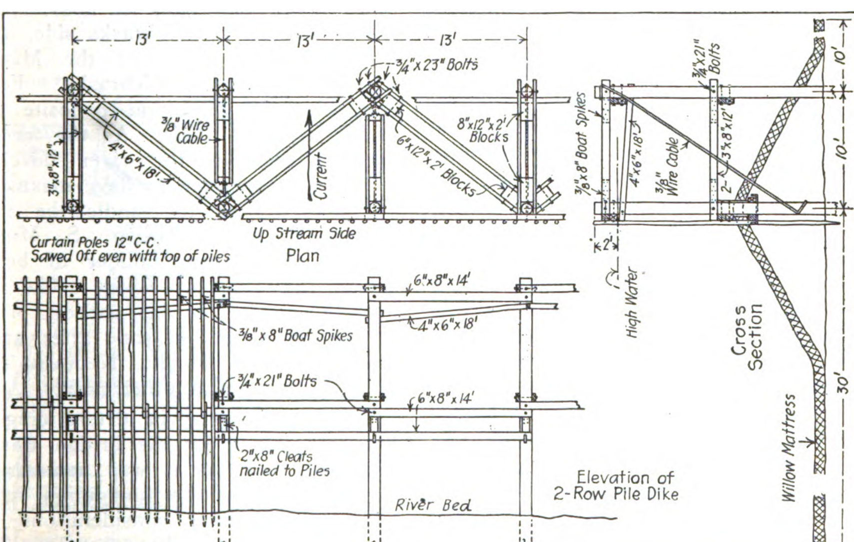
Concluding this discussion of the various causes of interference, it may be said that they divide into two great classes, natural and man-made. Progress is being steadily made against both of these enemies. As to the natural interference, there will always be a certain residuum of atmospheric disturbances and fading which will necessarily limit the distance from any broadcasting station at which reliable satisfactory reception will be possible. The various kinds of man-made interference, on the other hand, are curable and are of local character; it can be expected that more and more localities will be freed from the various types of this pest.

It has not been possible even to sketch herein all the ways in which important progress is being made upon radio engineering problems. I have not touched upon many interesting phases of radio which are applications of engineering rather than engineering itself. Increase of knowledge and of practical applications characterize all phases of radio. We are coming to have a picture of the machinery by which the waves are propagated. Remarkable discoveries are being made in the behavior

and potentialities of the waves of hitherto unknown frequencies. We are learning to direct the waves in a desired direction. The battle against interference is being won in spite of enormous increase in the use of radio. In all of these and its other phases radio engineering is a fascinating subject, and one perhaps unique in the character and rapidity of current progress.



LOCOMOTIVE CRANES ON DIFFERENT LEVELS ERECTING STEEL FOR THE BLAIR BRIDGE DESCRIBED ON THE FOLLOWING PAGES.



Reconstruction of the C. & N. W. Ry. Bridge Over the Missouri River Near Blair, Neb.

By O. F. Dalstrom*, M. W. S. E.

Presented November 17, 1924

Forty years ago steel was hardly accepted for bridge building. The Blair bridge was built mostly of wrought iron but it served its purpose and was taken down intact to be used elsewhere. A new structure capable of carrying twice the load was built on the old piers. Both new and old structures are described here. Building a bridge was only a part of the work required here. An enormous amount of work has been necessary to hold the shifting channel within predetermined lines.—Editor.

IN 1923 the C. & N. W. Ry. reconstructed its bridge over the Missouri River near Blair, Neb. This bridge was built in 1882-83. The superstructure, designed for the small engines and light cars of that day, was not strong enough for present day loads. The substructure, however, was of adequate strength. The four river piers were used in the reconstructed bridge without any remodeling, to carry the new spans. The piers and abutments of the approaches were remodeled to receive the new approach spans, which differed in type and detail from the old spans.

The old bridge, Fig. 1, was finished and put in service in 1883. Although the old superstructure has given way to a new and much stronger structure, the four main piers, after more than 40 years, are still in place exactly as built, carrying the new river spans. A description of the old bridge and the methods of construction are given here as a matter of historical interest, and as essential to a full understanding of the reconstruction in 1923. The information is taken from the official report dated 1886, made by Geo. S. Morison, Chief Engineer of The Blair Crossing Bridge, as it was then called, to Marvin Hughitt, President of the Missouri Valley and Blair Railway and Bridge Co.

In November 1881, Mr. Morison, acting under instructions from Horace Williams of the Executive Board, and J. E. Ainsworth, Chief Engineer, of the Sioux City and Pacific Railway, began studies to determine the best place for a bridge across the Missouri River near Blair, for a railway to connect the Iowa lines of the S. C. & P. Ry. with that company's lines in Nebraska. The Sioux City & Pacific Railway was incorporated on July 21, 1864. By construction and purchase its lines were extended on both sides of the Missouri River, so that by 1881 it owned, on the Iowa side of the river, a line from Sioux City to Missouri Valley and from California Junction to the east bank of the Missouri River; and on the Nebraska side, a line from the west bank of the Missouri River to Fremont, Nebraska. Ferries connected the lines on opposite sides of the river at Blair. As the territory on both sides of the river developed it became necessary to have means better than ferries to handle the traffic across the river. George S. Morison became the pioneer builder of bridges across the Missouri River. The Blair bridge was one of his earliest bridges across this river, but soon afterward he built others at Omaha, Nebraska City, Sioux City, and at other points.

The main factor in determining the proper location for the bridge was the depth to rock, as it was necessary to go to rock for the foundation of the river piers. Other considerations were (1) narrowness of channel to avoid excessive length of bridge, and (2) well

*Engineer of Bridges C. & N. W. Ry. Co.

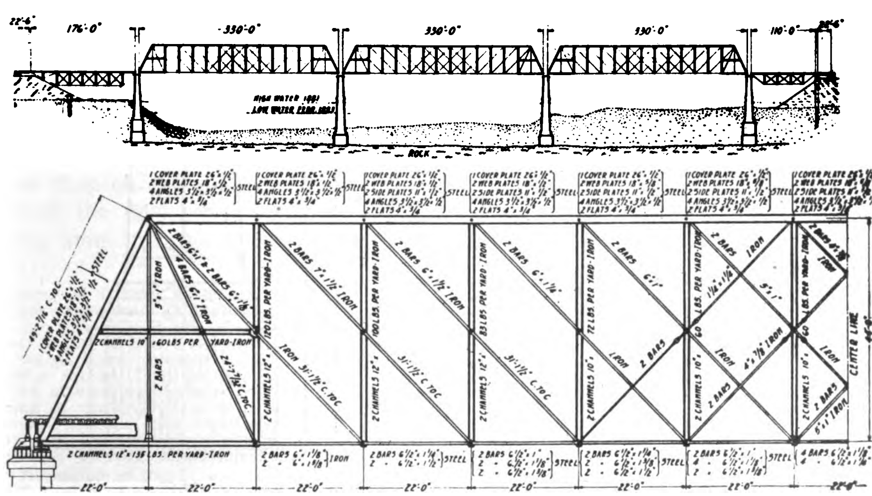
defined, stable banks that would hold the river channel to a fixed course. In April 1882 the place for the proposed bridge was fixed at the present site. Rock bottom at this point was about 52 feet below standard low water. The channel, however, was not unusually narrow nor were the banks high or stable, although quite well defined on the Nebraska side. On the Iowa side there was a very low bank, and at high water the river spread over a wide area east of the true channel. At a point 50 miles farther up stream, near Decatur, conditions were more favorable as to stability of banks, but the exceptionally bad bottom revealed by borings made this place impossible as a bridge site.

The construction of the proposed bridge was authorized by Act of Congress approved June 27, 1882. The plans of the bridge were approved by the War Department on August 1, 1882. The authority was issued to the Sioux City and Pacific Railway. All rights granted by Act of June 27, 1882, to the S. C. & P. Ry., were transferred in August, 1882, to the Missouri Valley and Blair Railway and Bridge Co., a subsidiary company incorporated August 31, 1882. The Missouri Valley and Blair Railway and Bridge Company was acquired by purchase by the C. & N. W. Ry., April 30, 1920.

The plan of bridge adopted, Fig. 1, provided for three 330-ft. through-truss spans over the river channel, with approaches consisting of one 110-ft. deck truss span and one 22-ft. 6-in. deck-plate girder span at each shore. The 110-ft. truss span in the west approach was replaced with a 176-ft. truss span after the bridge was completed. The necessity for this change is given in the description of the approaches. The total width of waterway provided for in the design was about one thousand feet. The clear head room was 50 feet above mean high water. The width of waterway necessary was determined by the width of the river at points some miles down stream from the proposed site, where the river, confined by banks on both sides, was somewhat less than 1000 feet wide, the waterway being clearly sufficient for the river at flood stage. The clear head room under the bridge was established by government engineers to provide adequate clearance for existing and for contemplated river traffic.

Substructure

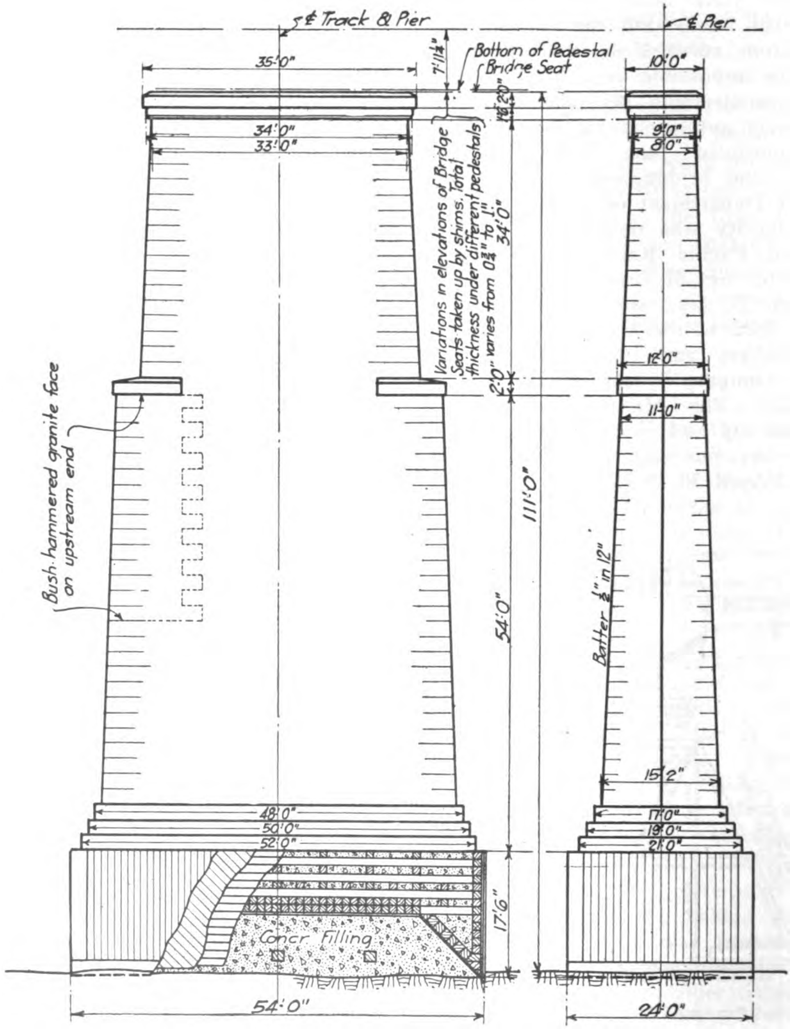
The substructure for the three 330-ft. river spans consists of four masonry piers on caissons sunk to foundation on rock. These four piers are the only elements of the original structure that



SECTIONS OF TRUSS MEMBERS.

remain unchanged in the new bridge. The piers under the shore ends of the 110-ft. approach spans were concrete-filled steel cylinders on pile foundations. The 22-ft. 6-in. girder spans at the extreme ends of the bridge extended shoreward from the cylinder piers, their shore ends resting on masonry abutments buried in the embankment. The purpose of the short girder spans was to fix the end of each embankment far enough back from the cylinder pier to bring the slope below the tops of the cylinders.

The river piers Nos. 3, 4, 5 and 6, Fig. 2, were founded on caissons sunk by pneumatic process. These four piers are alike in general dimensions, but Piers 4 and 5, near the middle of the channel, differ from the other two in the details just above the caissons. In Piers 4 and 5 the stone masonry begins at the tops of the caissons, about 17 feet above the cutting edge. In Piers 3 and 6 a crib 20 feet high and filled with concrete was interposed between the caisson and the first course of masonry. The cribs were built into Piers 3 and



6 for economy; but such cribs being much wider than stone masonry for the corresponding portion of a pier, they were not adopted for Piers 4 and 5 on account of the greater obstruction that cribs would offer to the current in mid-channel. Another special feature of Piers 4 and 5 is the bush hammered granite cutwaters at their upstream ends, provided on account of these piers being more exposed to the action of floating ice than the piers nearer the shores. All other masonry in the river piers is limestone.

The caissons for Piers 3 and 4 were built on a sand bar near the east bank of the river, and floated to place. The caissons for Piers 5 and 6 were built at the respective sites of those piers. At Pier 5 the depth of the water made it necessary to construct a staging on piles to build the caisson on. At Pier 6 the ground was above the water level and a pit was dug in which the caisson was built. The work on Piers 3, 4 and 5 was begun in the fall of 1882, and on Pier 6 in January 1883. The low water period for this section of the river is usually from August to March. The regular highwater period begins in March and extends over April, May, June and July. In planning this work it was apparent that all the piers could not be completed during the low water period. For this reason the work on Piers 4 and 5, near the middle of the channel, was given priority over the work on Piers 3 and 6, because the work on piers near the shores could be handled with less difficulty than on the mid-channel piers, under adverse river conditions. The following table gives data on the progress of construction of the four piers:

The stone for the piers was quarried at Mankato, Minnesota. It is an excellent grade of limestone, originally of a yellow color. Stone from these quarries had long been used in structures around Mankato and had given evidence of durability. The cut waters of the upstream ends of Piers 4 and 5 were of blue granite, quarried at St. Cloud, Minnesota. The face stones were laid in Portland cement mortar. The backing was laid in Milwaukee cement mortar, except that laid during freezing weather when Portland cement was used throughout. The specifications for the masonry were very exacting as to quality of materials and workmanship. They are given in full in Appendix A.

About 1905 a detail inspection was made of the entire surface above water, of the four river piers. The record of that inspection shows no evidence of deterioration of stone or mortar. There is a record of a number of cracked stones in every pier. These cracks were all vertical and apparently very fine, in no case extending across more than one stone. No cracked joints were shown in this inspection record.

When the reconstruction of the bridge was proposed, a new inspection of the piers was made to determine whether their condition and probable length of life would justify erecting the proposed new superstructure on them. This inspection was made on January 15 and 16, 1923, using a scaffold suspended from the span and lowered by stages from top of pier to water level. Every face stone in the four piers, above water level, was inspected.

The record of this inspection shows two kinds of weathering effects; some stones were pitted all over ¼ in. to ¾ in. deep, and were rough to the touch, as if some soluble ingredient had

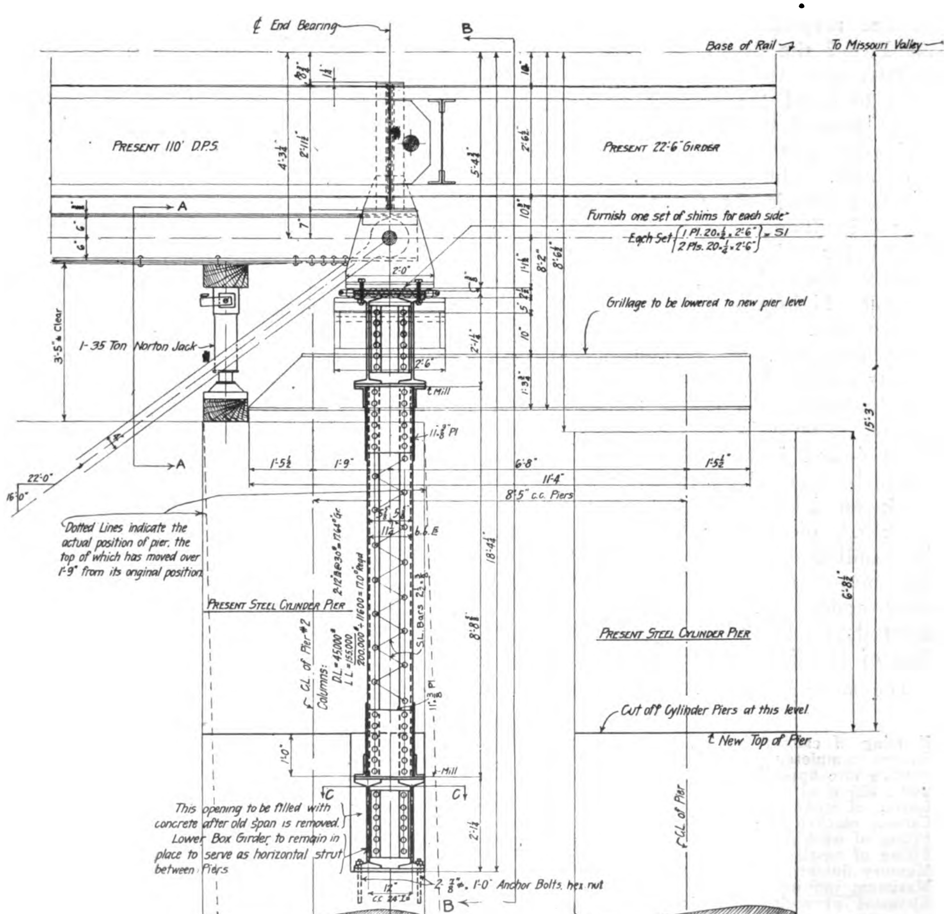
	Pier 3	Pier 4	Pier 5	Pier 6
Framing of caisson begun	Sept. 19:82	Oct. 12:82	Dec. 5:82‡	Jan. 23:83
Caisson completed (including conc.)	Dec. 21	Nov. 20	Jan. 12**	Mar. 14
Air pressure applied in sinking	Dec. 29	Nov. 22	Jan. 10	Mar. 17
Conc. filling of crib finished	Jan. 18	(No Crib)	(No Crib)	Apr. 2
Laying of stone masonry begun	Feb. 7	Nov. 23	Jan. 13	Apr. 5
Caisson reached final position	Mar. 2*	Dec. 15	Feb. 12	Apr. 14
Filling of working chamber begun	....	Dec. 18	Feb. 12	Apr. 17
Filling of working chamber finished	Mar. 5	Dec. 21	Feb. 15	Apr. 19
Masonry finished (pier completed)	Mar. 31	Jan. 29	Mar. 3	May 9
Maximum indicated air pressure	24 lbs.	25 lbs.	24 lbs.	29 lbs.
Elevation of rock foundation	528.8	525.7	524.7	525.5

* Sinking of Pier 3 was suspended on Jan. 6 and resumed Feb. 15.
‡ Staging for caisson of Pier 5 was begun Dec. 5.
** Lowering the caisson from staging with screws was begun Jan. 8.

been dissolved out. The other stones were wholly free from pitting, but many of them were spalling slightly. Fresh surfaces where spalls had dropped away recently and a few spalls still clinging to the stones, showed that the spalling was still going on. The loss by spalling or pitting, however, was so small that it was hardly appreciable except in one stone on the west side of Pier 3, near low water level, which had spalled off to a depth of nearly 6 inches over its entire face. This stone has since been faced with concrete.

The mortar in the joints was in excellent condition, no evidence of deterioration being found. The piers have never been pointed since they were built. Small dabs of mortar spilled on the lower courses during construction had hardened on the stones and could be dislodged only by a sharp blow with a hammer.

The number of cracked stones found on this inspection was greater than the number recorded on the previous inspection. There were also a few cracks at joints. All except two cracks in the stones were vertical, generally near the middle of the stone, and extended through only one stone. Two of the cracks were horizontal, one of them in a stone that showed signs of lamination. The largest cracks would barely



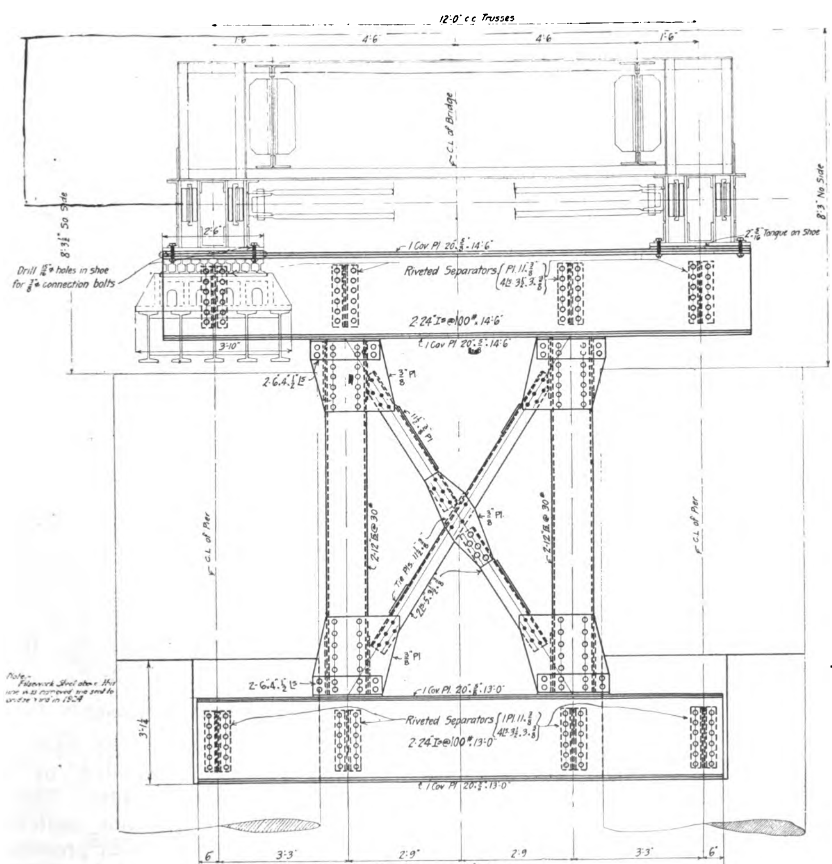
ELEVATION

admit the point of a knife blade, while the smallest were hardly more than visible. All of them appeared to be old cracks. The vertical cracks were probably caused by uneven bedding of the stones when laid, the stones cracking in vertical planes, under the action of the superimposed load. The cracking permitted the stones to adjust themselves to the uneven bedding and no further developmnets followed. On the east side of Pier 6, near the north end, is a joint crack running through five courses and through the connecting segments of the horizontal joints. There was no evidence of displacement of the stones, the crack being only about 1/16 in. wide.

The greater number of cracks appearing in the record of the 1923 inspection as compared with the 1905 inspection, may have been due to the greater thoroughness of the later inspection, or to the greater completeness of the record. If our theory as to their cause is correct, all the cracks found in 1923 had developed before the earlier inspection was made.

From the records of the inspection of 1923 it was estimated that the piers were still good for not less than 50 years, and probably much longer.

The piers under the shore ends of the 110-ft. approach spans consisted originally of two concrete-filled cylinders in each pier, built on pile foundations. The cylinders were 5 ft. in diameter, 12 ft. apart center-to-center, and connected by steel bracing from top to bottom. The shells were 5/16 in. metal.



SECTION B-B

The cylinders for the west pier were 42 ft. 9 in. long; for the east pier they were 13 ft. longer than those of the west pier, on account of the lower level of the ground line at the east pier.

In 1900 it became necessary to remodel the 2-cylinder pier in the east approach, making it a 4-cylinder pier with bolsters on top, on account of a slow westward movement of the east embankment. No change in the superstructure was necessary. The details of the remodeling are given in the description of the approaches. When the bridge was reconstructed in 1923, the pier was remodeled by cutting down the cylinders and lowering the bolsters as shown in Fig. 3.

On account of disturbances in the west embankment in 1884, described in detail under the subject "Approaches," it was decided that the end of that embankment should be kept farther away from Pier 6. Accordingly the 110-ft. span was taken out in 1885 and replaced with a new span 176 ft. long, the shore end resting on a concrete and I-beam grillage, 12x24x6 ft., buried in the embankment, which was sloped back to conform to the outline of the new span. The 22-ft.-6-in. girder span was re-erected at the end of the new span. The upper portion of the old cylinder pier was removed to a level slightly below the surface of the new slope.

The 110-ft. span taken out was re-erected in 1885 over the White River near Chadron, Nebraska, at what is now Bridge No. 663, Black Hills Division. It remained in service there until May, 1920, when it was completely wrecked by a freshet that swept the span off its pile piers and carried it some distance down stream.

In the reconstruction of the west approach in 1923 the 176-ft. deck truss span was replaced by two deck-plate girder spans and a steel bent. The substructure for the steel bent consisted of two separate concrete pedestals built on concrete foundation piles about 40 ft. long. These pedestals were placed 23 ft., 6 in. apart to permit the pile driver to work from the track with leads suspended outside the bridge, the vertical clearance below the span being too small for a pile driver. This accounts for the width of the bent at its base, which is considerably more than required for stability.

The old concrete and I-beam grillage at end of truss span, and the old abutment, were remodeled at bridge seats to fit the new girder spans. The new approach spans were so designed as to require but little remodeling of substructure.

When the plant for erecting the new superstructure was set up at the bridge site in 1923 a wooden water tank was built a few feet north of the north end of the west abutment to supply water for the boilers of the erecting equipment. Water leaking from this tank, and spilled in transfer to tank, softened the north side of the embankment, causing the north end of the abutment to settle slowly about 9 inches. Temporary blocking was put under the bearings of the span, and in the fall of 1924, the bridge seat and the back wall were built up to normal level with concrete. By that time the embankment was well dried out and no further settlement has occurred.

In the reconstruction of the east approach the old 110-ft. deck truss span was replaced with a deck-plate girder span of corresponding length. The old cylinder pier was cut down, the I-Beam grillages replaced at the lower level and a transverse bolster built of I-Beams set on the grillages to carry the girder span.

To carry the end of the deck truss span while the pier was being cut down and remodeled, a special steel bent was built and set in place under the bearings. The details of this bent and the arrangements for jacking the span are shown in Fig. 3 and Fig. 4.

West Approach

The approaches at both ends of the bridge originally consisted of timber trestles on 1-percent grades. The trestle at the west end was not contemplated in the original plan, which provided that this embankment should be finished to

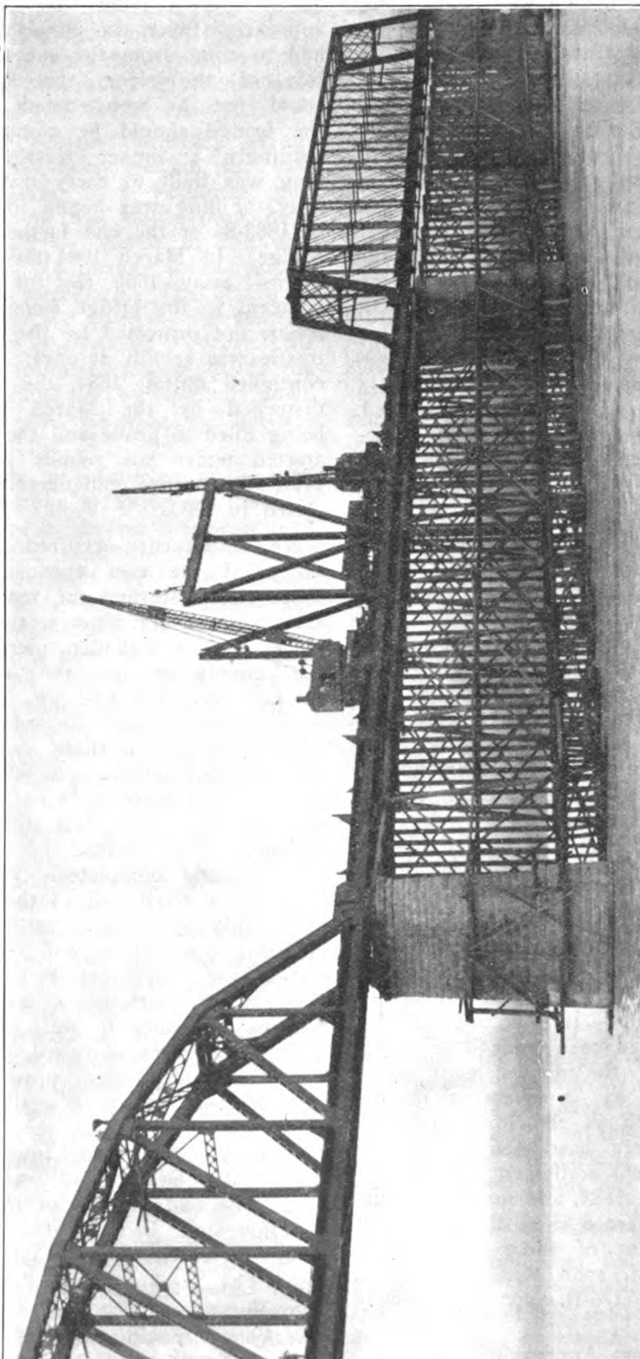
grade while the bridge was being built. When this embankment had been brought up to grade to within about 300 feet of the west end of the bridge as established, a settlement of about 6 feet occurred during the night of July 19, 1883. The ground at the sides of the embankment rose about 6 feet at the same time. Borings revealed a layer of soft mud below the top layer of hard material, evidently marking the course of an old channel. The filling was continued until the embankment was again brought to grade; settling continued during the progress of filling, the ground at the sides rising about 14 feet before equilibrium was established. It was estimated that the total settlement of the embankment was over 40 feet.

The embankment adjacent to the bridge was not carried up to grade at this time. The east end was leveled off at the full width of finished embankment about 35 feet below level of track on bridge, and a trestle about 220 feet long was built to carry traffic until the embankment could be finished. The embankment was finished to grade up to the end of the bridge in 1884, but almost immediately after completion a section adjacent to the bridge settled about 10 feet, carrying the cylinder pier down with it. The span carried by the cylinder pier was held to grade during the settlement by blocking laid up as the settlement progressed. This settlement was near enough to Pier 6 to produce a slight movement, the top of the pier being displaced about 9 inches toward the river. It was not believed that the pier had been cracked or otherwise damaged, the displacement being accounted for by compression in the timber cribwork in the lower part of the pier. There has been no disturbance or unusual settlement of the embankment since 1884, and no further displacement of Pier 6 since that date. It was on account of these disturbances that the 110-ft. span was replaced in 1885 by the 176-ft. span previously mentioned.

East Approach

The history of the east approach is quite different from that of the west approach. Since the material for filling had to come from the cut on the west side of the river, this embankment could not be constructed until after the bridge should be completed. Accordingly a timber trestle 3000 feet long was built to carry traffic temporarily. Filling was begun in the winter of 1883-84 at the end farthest from the bridge. In March 1884 the high water carried away 1600 feet of the trestle adjacent to the bridge, being all of the trestle not protected by the filling. The trestle was rebuilt at once. Filling was continued during 1884, the portion not disturbed by the March high water being filled to grade and the filling well started under the rebuilt portion that year. The entire embankment was completed in 1885.

No settlement occurred during the filling of the east approach such as those that disturbed the west approach. However, a very slow westward movement of the cylinder piers following the completion of the embankment showed that the end of the embankment was moving toward the river. There was also a slight vertical settlement of the cylinders, as would be expected. The records do not show when this movement was first noticed, but it probably began before the embankment was actually completed. As the pier carried the fixed end of the deck truss span, this span was carried westward with the cylinders and embankment. When the movement had carried the deck span westward a few inches it became necessary to shift the pedestals on the cylinders eastward, drawing the span back to original position to prevent it from crowding against the east river span. By 1900 the top of the cylinder pier had moved toward the river about 10½ inches, and was still moving. The end bearing of the span had by this time been shifted toward the east side of the pier as far as it could go. The west end of the span was crowding against the end of the adjacent river span making it necessary to repeat the shifting of the deck span. To remedy this condition and provide for



VIEW DURING CONSTRUCTION SHOWING PART OF COMPLETED NEW SPAN, MIDDLE SPAN ON FALSEWORK AND OLD SPAN READY TO BE TAKEN DOWN.

future movement of the pier, two cylinders similar to those in the original pier but only 35 ft. long, were set 8 ft., 5 in. back of the old cylinders and filled with concrete. The old cylinders were cut down about one foot and two I-Beam grillages filled with concrete were set on top of the old and the new cylinders, parallel to the axis of the bridge, forming bolsters for carrying the truss bearings.

When the cylinder pier had been remodeled the deck span was moved back to its normal position. Also at this time the fixed and expansion bearings of the span were interchanged, the expansion bearing being transferred to the cylinder pier so that any further displacement of this pier would take place without displacement of the span. The slow movement of the pier continued after the new cylinders had been put in, all the cylinders moving with the embankment. By 1920 they had moved so far that the base castings under the bearing rollers were almost in contact with the diagonal truss members. This was corrected in 1921 by simply sliding the base castings back a few inches and anchoring at a new place on the bolsters.

In 1921 a quantity of heavy stone from the abutments of an old bridge near Missouri Valley was put in along the foot of the slope where it projects into the river, the outer layer being stones of boulder size. These large stones being massive enough to withstand the ice and the current at high water, have protected the embankment against scour and no further displacement of the pier has been observed since this was done. The total displacement of the top of the old cylinders from their original position is 1 ft. 9 in.

THE OLD SUPERSTRUCTURE 1883

The spans composing the original superstructure were built up of a combination of steel and wrought iron members, with cast iron pedestals. The following quotation from the specifications gives the distribution of the steel, wrought iron and cast iron:

"In the through spans the top chords, the end posts, the nine central panels of the bottom chords, the bolsters, rollers and bearing plates, and all pins of every description, will be steel. The other parts will be of wrought iron, except the pedestal castings and portal ornaments, which will be of cast iron. The deck spans will be entirely of wrought iron, except the pins, rollers and bearing plates, which will be of steel, and the pedestal castings."

This bridge was built at the time when steel was coming into use as bridge material, but had not wholly superseded wrought iron. Preference was given to steel in certain important members of the large spans. Wrought iron was specified for the web members, the floor system and the laterals; and for the entire deck spans, except pins, rollers and bearing plates. While taking this advanced position in the use of steel, the designer required that the material should be made under very exacting specifications and subjected to rigid tests. The specifications for shop work and field work were equally exacting. The specifications for the superstructure are given in Appendix B.

The record of tests of full size steel eye bars is given in appendix C. These tests were made at Watertown. A few of the bars failed to meet the requirements of the specifications, but the report shows that these bars would have been condemned without the full size test. There are no test records of the wrought iron material now available.

The steel blooms were manufactured by the Cambria Iron Co., of Pittsburgh, and the steel shapes rolled by Carnegie Brothers & Co., at the Union Iron Mills, Pittsburgh. The fabrication was done by the Keystone Bridge Co., of Pittsburgh.

The live load provided for in the trusses was 3,000 pounds per foot of track, "except that, in proportioning the web members, the excess of maximum stress in any member above the stress in that member under a uniform load of equal intensity, was taken on a basis of 5,000 pounds per linear foot, instead of 3,000 pounds." The floor system was proportioned for a live load of

5,000 pounds throughout. The top lateral system was designed for a wind load of 300 pounds per linear foot, and the bottom lateral system for 500 pounds per linear foot, taken as moving loads. In his report Mr. Morison offers the following comment on this loading:

"The trusses were not proportioned to carry any particular class of locomotives or cars now in use, but for general conditions which are believed to include the heaviest class of rolling stock which is ever likely to be used."

Within 20 years after this was written, and within Mr. Morrison's lifetime, the C. & N. W. Ry. was operating over this bridge engines heavier than the load it was designed for; and within 25 years was operating in this vicinity engines too heavy to be allowed on the bridge. The rating of all the spans, based on Cooper's loading, was E-25.

The superstructure was erected on falsework built in the river and on the banks, and reaching up to the bottom chords. The falsework for the east river span was set on blocking laid on the ground; for the other two river spans piles were driven to carry the falsework. The steel was erected with a traveler of sufficient capacity and reach to place any member of the bridge from its position on the deck of the falsework.

The deck span of the west approach was erected in June, 1883. The construction of the falsework for the river spans was begun on August 5. The erection of the river spans was begun August 16 and completed October 22. The deck span of the east approach was erected in September, while the river spans were going up. The bridge was formally tested by a committee of engineers on October 27, 1883, and opened to traffic on that date. The report of the testing committee is given in Appendix D.

The table given below gives the weight of metal in the different spans:

The entire superstructure was in excellent condition when taken down. No reinforcing and very little repair work had been done on any of the spans during their forty years of service. In 1900 the short sections of eye bars in the adjustable counters in all three river spans were replaced with new pieces, on account of defects that developed in the original bars. In 1920 the connection angles in a number of stringers of the river spans were found to be cracked in the fillets and were replaced with new angles—12 pairs in all. In the same year several floor beams in the 110-ft. and 176-ft. approach spans were repaired where they had developed cracks in the webs near the bottom of the stringer connections, evidently due to the thrust from the ends of the bottom flanges of the stringers. In 1923 some cracked connection angles of stringers in the deck truss spans were on the order to be replaced, but the spans were taken out before it was necessary to do the work. The cause of these failures in the floor member details, at this late date, was probably the heavy cars which by 1920 were more severe on the floor members than the locomotives. There had been no increase in the weight of locomotives over the bridge for about 20 years.

There was no evidence of deterioration of the structure when taken down. There were no shoulders on the pins, no elongated pin holes. A number of the pins stuck fast in the top chords and the posts. Those in the chord that could not be loosened were burned off. Those in the posts were left there, the eye bars being simply slipped over the ends of the pins.

The history of this bridge is a good demonstration of the endurance of such a structure under favorable conditions of service and maintenance. It represented the best class of material and workmanship of its day. Traffic was always comparatively light, only a few

	Three 330 ft. Spans	176 ft Span	110 ft. Span	Total
Steel	884,548	6,753	4,979	896,280
Wrought Iron	1,447,148	238,550	110,503	1,796,201
Cast Iron	57,322	4,325	8,955	70,602
Totals	2,389,018	249,628	124,437	2,763,083

trains a day each way. Situated at the summit of long, heavy approach grades, it was never subjected to the high speed of trains, which could scarcely attain the speed limit of 10 miles per hour allowed. Loading was always well within the capacity of the bridge until recent years when trains of heavy cars probably produced stresses in light truss members above the limits allowed in good practice. Rigid inspection was maintained by General Bridge Inspector and by Division Inspectors. A special foreman living near the bridge, looked after the bridge and the shore protection. A watchman posted on the bridge in daytime patrolled the bridge and prevented trespassing. After forty years of service, there were no indications from which to determine the limit of life of the structure under existing conditions. It looked good for forty or fifty years more of the same kind of service, and gave no means of fixing the limit, since there was no measurable deterioration.

The following tension tests were made on test specimens cut from members of the 110-ft. and 176-ft. Deck Truss Span. All of the pieces tested were wrought iron.

The three river spans were taken down in shape for re-erection. One of these has been assigned for re-erection on the C. & N. W. Ry. over Wind River near Riverton, Wyoming. The other two spans are stored at Blair. The deck spans were taken down as scrap, their size and shape making it impracticable to find a place to use them.

THE NEW SUPERSTRUCTURE 1923

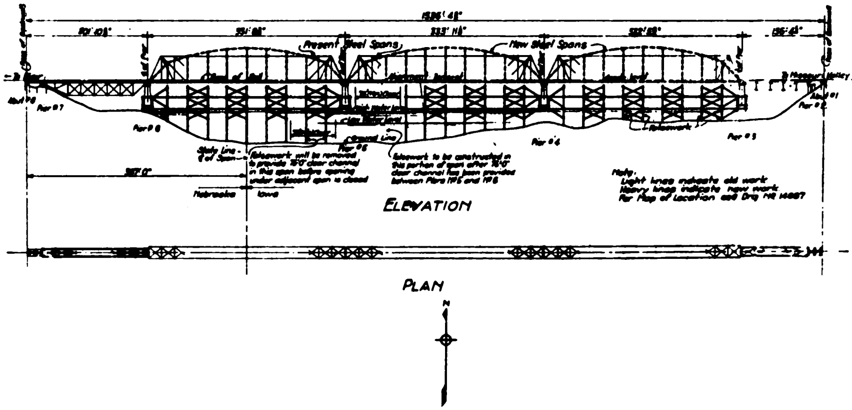
The new superstructure, built in 1923, was designed for Cooper's Class E-60 loading. It was designed and built under the American Railway Engineering Association Specifications for Steel Railway Bridges, Edition of 1923. Fig. 5 shows the general plan of the new superstructure. The new spans were fitted to the four old river piers without any remodeling of the piers. In order to make the three river spans alike it was necessary to load Pier 6 eccentrically. The center line of truss bearings is 6 in. west of the center line of pier, and the center line of girder bearings is 2 ft., 11 in. west of the center line of pier. This eccentricity of loading was due to displacement of Pier 6 toward the river, as described under "Substructure." As the pier was of ample strength for the new loading, and as the eccentricity of loading was in the direction opposite to the displacement of the pier, it was considered of too little importance to justify a special length of span to fit this pier.

The old deck truss spans of the ap-

Identification No. of Specimen	Bridge Member from Which Specimen Was Taken.	Yield Point	Ult Tens. Strength
From 110-ft. Span			
2	Web of Channel—Vert. Post	41400	*54200
4	Cover Plate—Top Chord	42300	†‡53000
5	Web of Channel, Hor. Strut	32000	48200
From 176-ft. Span			
18	Web of Channel, Hip Vert.	33200	51100
19	Web Plate—Top Chord	31200	38300
21	Web of Channel, Vert. Post	43700	48700
22	Cover Plate—Top Chord	26500	45800
23	Web of Channel, Vert. Post	36400	50500
26	Web of Channel, Vert. Post	29600	48800
27	Web Plate—Top Chord	28900	46100
28	Cover Plate—Top Chord	34100	51000
29	Eye Bar, 6"x1 $\frac{9}{16}$" Bott. Chord	34500	42200
30	Eye Bar, 5"x1⅝" Bott. Chord	28700	39200
31	Eye Bar, 5"x1⅝" Bott. Chord	27420	44880
32	Eye Bar, 5"x1⅝" Bott. Chord	29200	46420
35	Eye Bar, 4"x¾"—Web	31200	45600
36	Eye Bar, 5"x1" Bott. Chord	28300	46500
45	Bott. Flge. Angle—Str.	31000	‡44900
49	Top Flge. Angle—Str.	....	‡32600
50	Top Flge. Angle—Str.	....	*‡39100

* Square break.
† Flaw.
‡ Laminated.

The pieces cut from the bridge members in the field were stamped with a stencil. This stencil cut remained on the finished test specimen between the gauge points. All the specimens except Nos. 2, 4, 23, 45, 49 and 50 broke at the stencil cut, which affected the results of the tests. This accounts for the irregularities in this table. The test specimen showed a uniform fine-grained, fibrous material in every specimen, indicating a very good quality of wrought-iron.



proaches were replaced with deck-plate girder spans, and the substructure remodeled accordingly. The 176-ft. span of the west approach was replaced by two short girder spans and a steel bent, a more economical type than the single long span.

Design and Fabrication

The new superstructure was designed by the American Bridge Company and fabricated at their Gary plant. Thorough inspection of all shop work was maintained by the Railway Company. The trusses were all assembled for reaming of field connections. Field connections of floor beams and stringers were reamed to iron templets. All members reamed assembled were match marked. The material came through the shop in excellent form, there being practically no extra work necessary to pass final shop inspection.

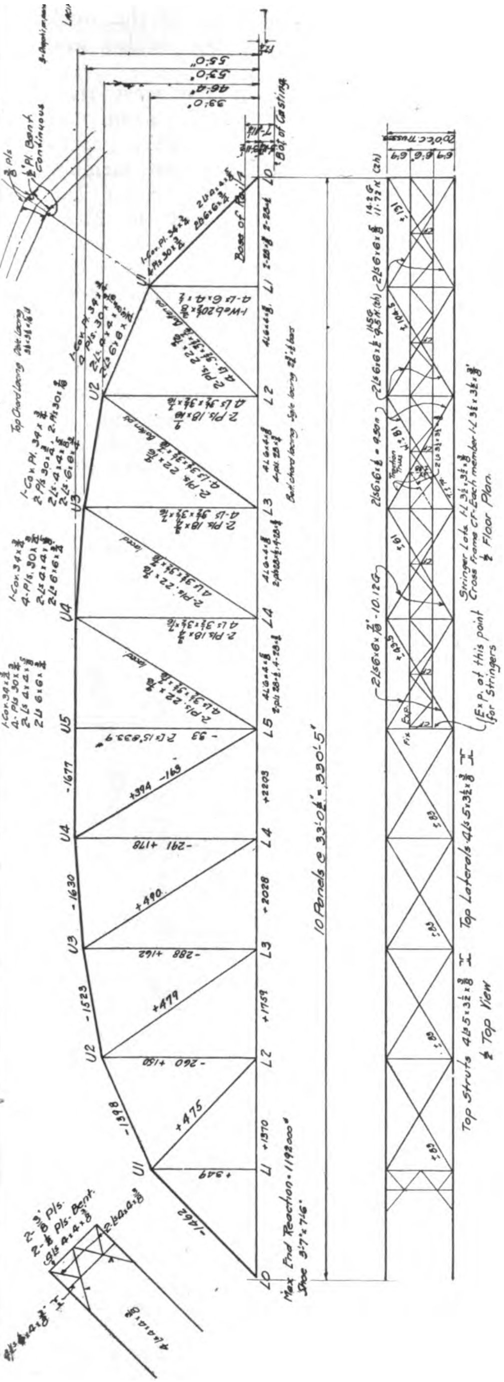
The Bridge Company made an exceptional record in the delivery of the fabricated material. The instructions to proceed with the design were transmitted to the Bridge Company, February 5, 1923. Preliminary approval of joint details was given by Railway Company in advance of approval of shop plans, to expedite ordering material from the mills. The first shipment of fabricated steel left the shop on August 30, and following that date, material went forward continuously in the order required until the last shipment, which was made on November 27.

Erection

The contract for erection of the new superstructure was awarded to the American Bridge Company. This contract, which was distinct from the contract for design and fabrication, included the construction and removal of the falsework, the removal of the old superstructure and the erection of the new. The Railway Company furnished all the piles and lumber for the falsework, but none of the framing iron or the steel I-Beams for the falsework deck. The contractor was required to take down the three river spans without damage to the members, so that these spans could be re-erected elsewhere. The approach spans were to be taken down and loaded, in convenient way, except that stringers were not to be damaged, and were to be loaded separately in cars. These stringers were of a size and length making them good material to keep on hand for ordinary falsework.

A convenient storage yard was available on the west bank of the river just north of the bridge. A spur track used for handling bank protection materials ran along side this space, but the rails in the track were too light to carry the locomotive cranes to be used. The Railway Company, therefore, relaid with heavier rails about 800 ft. of the old track, also laid about 800 ft. of new track parallel to this spur, to serve as a passing track for material cars and erecting equipment.

The falsework for the three river spans, designed by the American Bridge Company, consisted of framed bents on piles. On the bents were set the



I-Beams, 24 in. x 115 ft. x 36 ft., which carried the traffic and the structures during the removal of the old and the erection of the new. The piles furnished were Oregon fir, 70 ft. long, very large and straight. In approving the falsework plan, the Railway Company changed the longitudinal and transverse braces from nominal small sizes to 12x12 in. and 8x16 in. in order to secure good bridge timber from the salvage. This extra-heavy bracing rendered good service later when a sudden rise of the river threatened to destroy the falsework in the west channel span.

The program for the field work contemplated the driving of the piles in the river as soon as the high water of June had subsided. Driving was to begin in the west river span, working eastward across the river. With this plan in view the Railway Company secured piles and timber from the Pacific coast districts, which began to arrive in June. The contractor moved in with equipment, set up camp and had everything in readiness by the end of July. Pile driving began on August 3. On August 27 pile driving for the west span was completed, and on August 29 the framing for the west span was completed. Pile driving for the second span followed immediately after completion of the first span. While the driving was under way for the second span, there was a sudden rise of river, starting on October 4 and reaching an elevation of 588.50 on October 10. This was an unprecedented stage for that time of year, being only 2.4 ft. below the high water stage of the previous July. The river at such stages always carries great quantities of drift, including logs and large trees. The west span, where the falsework was in place, was over the main channel of the river. Construction was stopped during the rise of the river and all efforts were directed toward protecting the falsework by dislodging drift that caught among the piles. The falsework was saved with only slight damage, but at considerable cost to the contractor. The high water caused a delay of about seven days in the schedule of work.

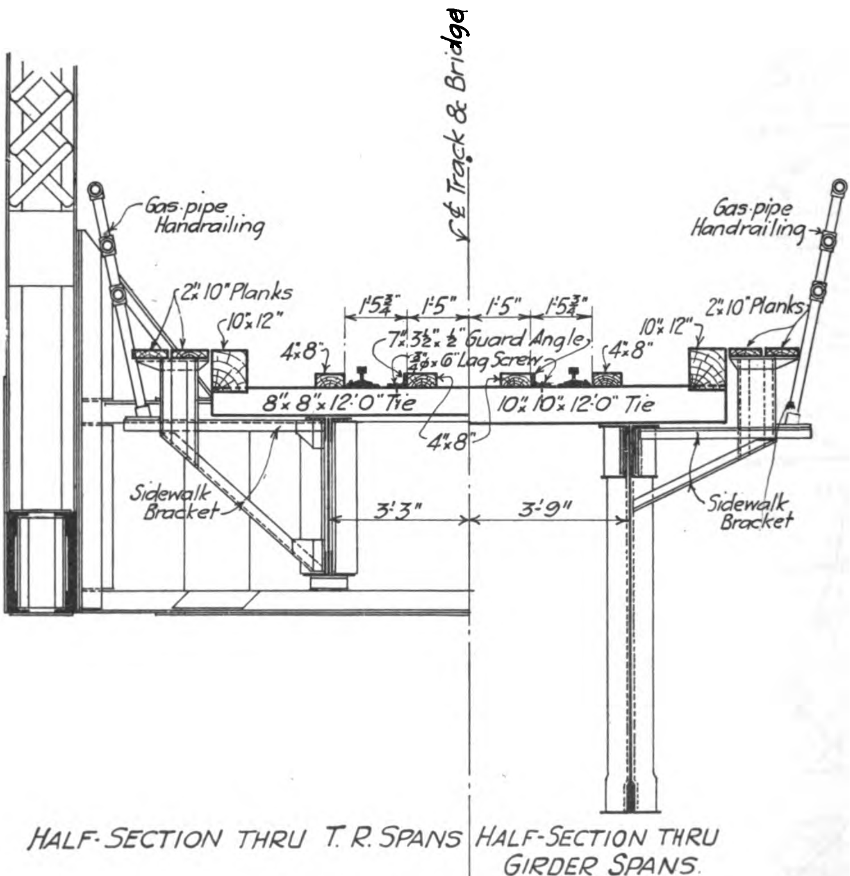
No falsework was provided for the erection of the approach spans. The 176

ft. truss span in the west approach was shifted northward 19 feet and landed on temporary pile piers, and the new spans and bent erected with cranes working from both levels. Traffic was suspended about 10 hours while this change was being made. The old truss span in the east approach was cut up in place with Oxweld outfits and loaded direct into cars. The new deck girder span was erected by using two locomotive cranes, one at each end, to set the girders in place. Traffic was suspended 6½ hours for this operation.

There were only two periods of suspension of traffic in the entire program of erection. Some interruptions to train movement occurred when it was necessary to hold trains until the locomotive cranes could let go of the work in hand to move off the bridge and get in the clear.

Erection of steel in the west river span was begun October 13. From that date erecting and riveting were practically continuous until the last member of the east river span was erected December 22. The 110-ft. and the 22-ft., 1 in. girder span of the east approach were erected December 19. The riveting of the truss members was completed January 15, 1924. The erection of the brackets for planking and handrailing followed the other work and was completed January 19. This completed the work of the erection contractor.

The thoroughness with which the work of the contractors for fabrication



DETAILS OF DECK
Scale: ⅜" = 1'-0"

and erection was planned and executed is demonstrated by the beginning of delivery of steel at bridge site within five months after receiving the order; and by the completion of the entire program of erection, including construction of the falsework and the removal of same, in a little more than six months.

Deck and Track

The type of deck is shown in Fig. 5A. Ample provision is made for protection of deck and bridge against damage by derailments. The steel guard angles and 4x8-in. guard planks protect the ties against damage by ordinary derailments. The 10x12-in. guard rails notched over the ends of the ties and bolted to every tie, hold the ties against bunching by derailed trucks, and prevent derailed cars from drifting into the trusses.

The free movement of rails and expansion ends of spans, independent of each other, is provided for in five expansion joints in the rails, conforming in position to the expansion ends of the spans. There is an expansion joint in the rails at each end of the bridge. This protects the bridge against any damage from the movement of the rails in the track beyond the ends of the bridge.

The deck, track and railing were placed by Railway Company forces.

The following table gives the tonnage of steel and iron in the new superstructure:

	Pounds
Three 330 ft. 5 in. through spans	4,563,528
One 110 ft. deck span	223,999
Two 88 ft. deck spans	283,804
Two 24 ft. deck spans	25,726
One Bent	25,322
Total weight	5,122,379

By comparing this table with the corresponding table for the old superstructure, it will be noted that the material in the three river spans of the new bridge is almost twice the weight of that in the corresponding spans of the old bridge. The other spans cannot be compared directly on account of the differences in type and span length.

The following table of costs of the original bridge, approaches and protection works are taken from Chief Engineer Morison's report:

The cost of the reconstruction carried out in 1923 and 1924 was as follows:

Substructure	$ 8,476.42
Superstructure	432,278.66
Total	$440,755.08
In the accounts there appears a credit for material recovered from the old spans and from the falsework, amount	2,978.04
Net cost of reconstruction	$437,777.04

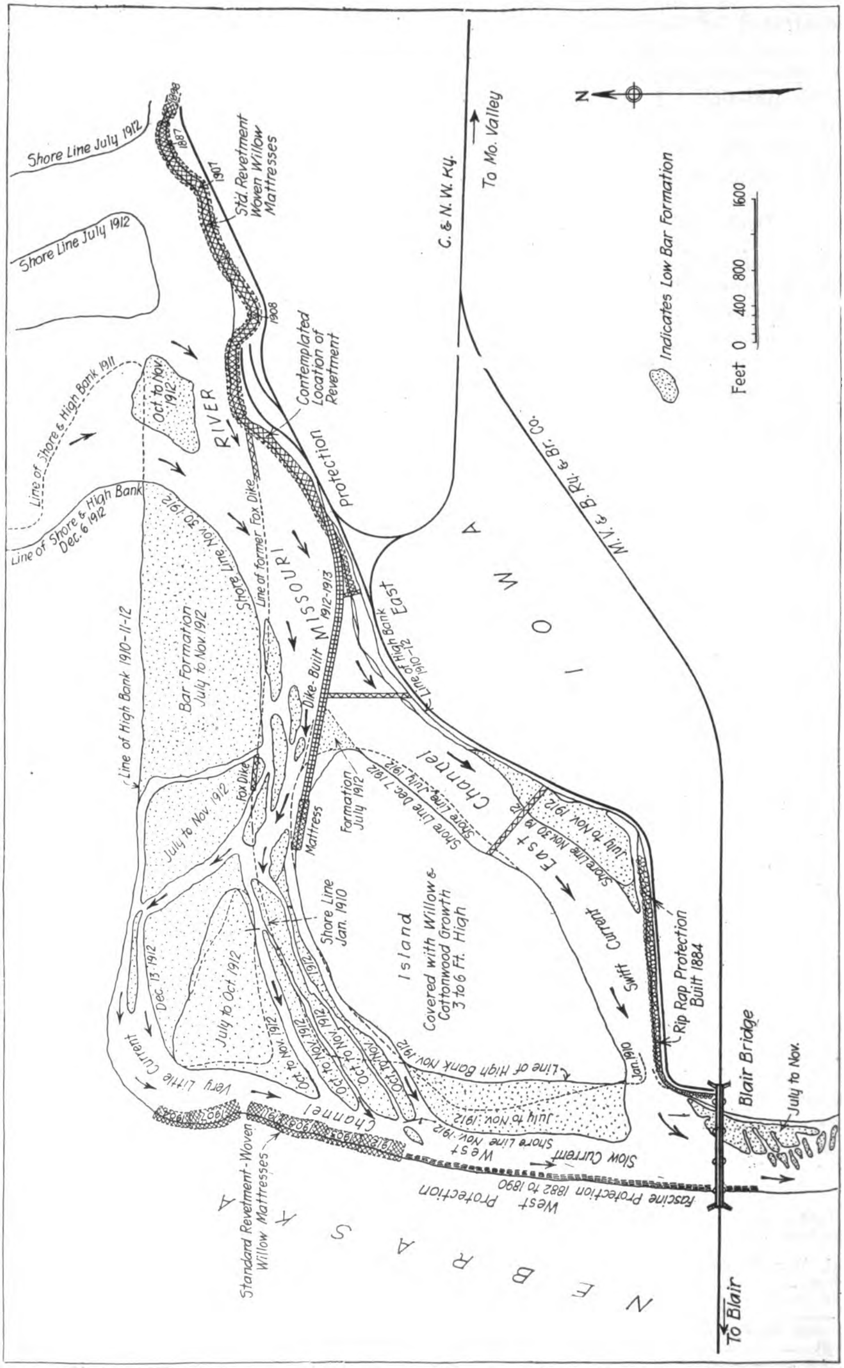
RIVER RECTIFICATION

At the Blair Crossing there were no high banks or bluffs such as elsewhere held the river to a well defined channel. It was recognized, when the site was selected for the bridge, that rectification works and shore protection would be necessary to hold the channel under the bridge. The greater part of this work was required on the east side of the river. Here the bank was lower than on the west side, and an old slough cut across the line of the approach about 2,000 feet east of the end of the bridge.

The rectification and shore protection works consisted of three distinct parts: (1) The West Shore Protection; (2) The East Shore Protection; (3) The Dike, also on the east side. Fig. 6 is a map based on a survey made in 1912, and gives the record of construction to that date.

The west shore protection followed a line which was laid out with a view to preventing the channel working to the west of Pier 6. It started at the bridge, in line with Pier 6, and extended northward about half a mile.

	Cost Exclusive of Freight Charges	Freight Charges	Total
Substructure	$190,383.39	$ 36,440.80	$ 226,824.19
Superstructure	200,336.68	6,188.80	206,525.48
Total, Brg. Proper	$390,720.07	$ 42,629.60	$ 433,349.67
Approaches	181,655.97	9,044.35	190,700.32
Protection works	214,238.73	187,462.08	401,700.81
Tracks	45,915.56	1,073.99	46,989.55
Building and tools	17,547.01	639.18	18,186.19
Real estate	9,112.76		9,112.76
Engineering	27,051.54		27,051.54
Total	$886,241.64	$240,849.20	$1,127,090.84



MAP SHOWING BRIDGE LOCATION AND RIVER BANK PROTECTION WORKS.

It consisted of a trench excavated along the established line, 32 ft. wide on top, the shore side on a slope of 1½ to 1, while the slope on the river side was ¼ to 1. The excavation was carried as deep as the water level at the time would permit. The trench, when completed was filled with heavy rip rap. When the river later cut through to this protection, the heavy stones in the trench dumped themselves into the water, forming a base on which the protection was restored by building up with fascines and stone.

The west shore protection was started in 1882 and completed in 1883. Considerable repair work was done in 1883 and 1884, but by 1885 the shore line had become practically fixed and stable. Occasional repairs have been made since that date. Extensions northward were made in later years until by 1904 this protection extended a mile and a quarter up stream from the bridge. In these extensions, constituting more than half of the entire length of the present protection the usual mattress and stone construction was adopted instead of the stone filled trench.

Occasional repairs have been made to the west shore protection since completion, but the cost of maintaining this protection has never been heavy.

The shore protection on the east side was at a point nearly two miles up stream from the bridge. The starting point was an old transfer landing. It was constructed along an arbitrary line to which the channel was to be held. Fascines were used throughout the protection. They were of the usual type for this kind of protection, consisting of bundles of brush—willow and cottonwood—bound with wire, and weighted with a quantity of stone in the interior sufficient to sink the fascine in water. The layer of fascines was overlaid with heavy rip rap. Later, as the fascines settled under the action of the water, more were added on top until the protection was stable.

About 1,000 feet of the shore was protected this way in 1882. Shortly after it was finished it became necessary to protect, in a similar manner, a point about half a mile nearer the bridge. A part of the later construction consisted of an earth levee with stone facing.

The dike was built much nearer the bridge than the early shore protection. The purpose of the dike was to form a barrier to divert the current at high water stage away from the east approach. The west end of the dike was fixed at a point about 600 ft. north of Pier 3. From this point the dike extended eastward diverging from the line of the approach at an angle of about 5 degrees. The west 500 ft. of the dike consisted of a willow mattress 150 ft. wide loaded with stone, on which were laid additional mattresses narrower, but of similar construction, until the required height was attained. A short return was constructed down stream from the west end.

The portion of the dike eastward from the mattress work consisted of earth embankment, the slopes of which were protected by fascines. This portion extended eastward about three-quarters of a mile, crossing the old slough channel, where it took the form of a pile bridge filled with brush and stone and covered with earth.

To prevent the water racing along the north side of the dike, five spurs, each 50 ft. wide and 300 ft. long were built projecting at right angles to the dike. These spurs were of mattress and stone construction similar to that of the main dike.

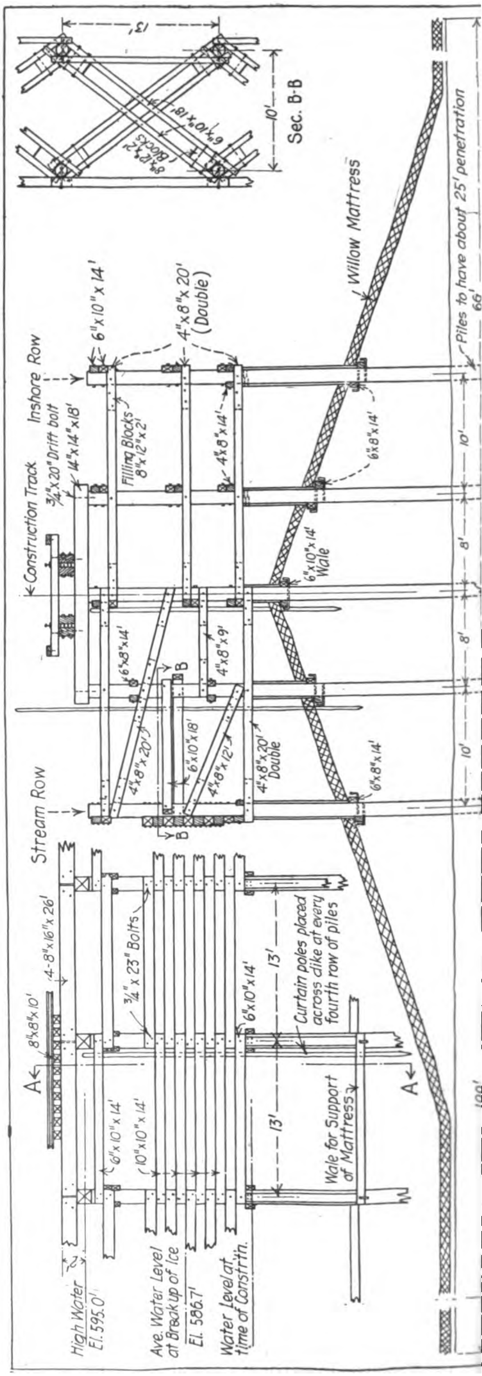
In the spring of 1884 the ice went out of the river with abnormally high water, ran over the dike and carried away part of the trestle approach to the bridge. The portion of the dike built of earth was nearly obliterated. When the water had subsided, it was found that the rectification works, although partly destroyed, had served their purpose; the slough channel had disappeared completely and a smooth, unbroken sand bar extended to the east end of the bridge.

The damaged dike was rebuilt the same year. In the reconstruction a more substantial form of mattress was adopted. This was of woven willow 100

ft. wide, similar to the mattress constructed by the Government in its protection works on the Missouri River. The mattress was covered with stone and a stone embankment was laid to carry a track; this embankment was gradually raised by adding stone until brought to the required height which was above the high water stage of 1881. In the reconstruction the new dike followed the line of the old dike to a point near the west end where it curved southward on a 300 ft. radius and extended southward across the bridge line immediately east of Pier 3.

The rectification works on the east side have occasioned heavy expenditures in repairs and reconstruction. New dikes in different locations have succeeded the original dike, the location of each new dike being determined by the channel conditions at the time. About 1900 a dike approximately a mile long was built, starting at a point on the shore about two miles upstream from the bridge. This dike extended in a slightly curved line almost due west from the starting point. This came to be known as the Fox Dike. It consisted of rows of piles well braced together and a row of curtain poles. A woven willow mat loaded with stone was laid down on the river bed, extending some distance each side of the barrier. By 1912, when the survey was made for a new dike, there remained only a few hundred feet of the Fox Dike—a broken segment at each end.

The most extensive reconstruction was carried out in the winter of 1912-13. At that time a channel had formed between the east bank and a large island covered with several years' growth of willow and cottonwood. This channel threatened to destroy the shore protection, and with it the east approach of the bridge, at high water. Accordingly a dike was constructed from the shore to the upper end of the island. This dike, which was half a mile long, consisted of five rows of piles framed and rigidly braced together. The three intermediate rows carried a deck and material track. The woven willow mattress forming a part of this protection



was 166 ft. wide, 100 ft. of which was on the stream side of the fender row of piles. The details of the dike and position of mattress are shown in Fig. 7. At the island the mattress was extended about 500 ft. beyond the dike proper. In addition to the main dike, auxiliary dikes were constructed farther down stream as obstructions to currents that might form below the main dike. These auxiliary dikes contained two rows of piles and a mattress 50 ft. wide, as shown in Fig. 7A. The total cost of dike and mattress and the auxiliary dikes constructed in the winter of 1912-13 was about $280,000. This dike served its purpose by filling up the channel along the east shore and turning the water back into the west channel.

In 1917 a levee of earth was constructed on the down stream side of the dike. The line of the levee was parallel to the dike from its shore end to a point about 2000 ft. out, where it diverged at an angle of about 30 degrees down stream, and continued in that direction about 600 ft. The levee was covered with a mat 150 ft. wide loaded with stone; about 100 ft. of this mat extended up stream from the levee. The dike was removed up to the point where the levee diverged from the line of the dike. The remaining portion was left as a barrier to protect the outer portion of the levee from swift currents. From 1919 to 1921 an apron 1200 ft. long was laid on the stream side of the levee, beginning at the shore end. This apron was 75 ft. wide, similar to the original mat, which had fallen to pieces or sunk out of sight along the shore end of the levee. The levee is still in good condition throughout its entire length. Some repairs to the shore protection farther up stream are contemplated in next year's program.

The shore lines and river conditions immediately up stream from the bridge are now about as near stable as they have ever been. The levee has held the river out of the east channel since 1917, and with proper attention a few years longer will be practically permanent. The large island at the west end of the dike in 1913 has been reduced to less than half its original size, the channel having cut away the west portion. This gives the channel an easy turn direct toward the bridge, instead of against the west bank of the river where it flowed when the dike and the island controlled the direction of flow in 1913 and for some years thereafter.

Ever since the bridge was built, the river up stream from it has been kept under control only by effective measures taken before conditions became dangerous. Since the dike was built 12 years ago, there has been little disturbance of the shores, but this cannot be taken as assurance of permanence. In dealing with the Missouri River nothing can take the place of judicious safeguards and eternal vigilance.

The reconstruction of the bridge was carried out under the general direction of the Railway Company's Engineering Department, W. J. Towne, Chief Engineer, and under the immediate direction of the Engineer of Bridges. Mill inspection of material was made by the Company's Engineer of Tests, H. D. Browne, and all shop inspection by the Robert W. Hunt Company. The field work was under the general direction of C. F. Womeldorf, Division Engineer of the Eastern Division. F. K. Brewster, Assistant Engineer, was in immediate charge of the field inspection and of the Railway Company's other field work at the bridge site. The American Bridge Company was the contractor for the design, manufacture and erection of the superstructure. The Bates & Rogers Construction Company was the contractor for the new concrete pier.

APPENDIX A

Specifications for Masonry—1882

(By Geo. S. Morison)

The masonry will be first-class rock-face work, laid in regular courses, to be built of limestone from the quarries near Mankato, Minnesota, except the up-stream starlings of Piers 4 and 5, which, for a height of 30 feet, beginning about 8 feet below low water, will be of granite.

The piers shall conform in all respects to the plans furnished by the engineer.

No course shall be less than 16 inches thick, and no course shall be thicker than the course below it.

The upper and the lower bed of every stone shall be at least one quarter greater in both directions than the thickness of the course, and no face stone shall measure less than 30 inches in either horizontal direction.

In general, every third stone of each course shall be a header, and there shall be at least two headers on each side of each course between the shoulders. No stone will be considered a header that measures less than 5 feet back from the face. The headers shall be so arranged as to form a bond entirely through the pier, either by bonding against a face stone in the opposite side of the course, or by bonding with a piece of backing not less than 3 feet square, which shall bond with a face stone on the opposite side. In all cases the interior bonding shall be further secured by placing in the course above a stone at least 3 feet square over the interior joints. Special care shall be taken with the bonding of the ice-breaker cut-water, the stones of which shall be so arranged that the face stones are supported from behind by large pieces of backing.

All joints shall be pitched to a true line, and dressed to ¼ inch for at least 12 inches from the face. Beds, both upper and lower, shall be pitched to a true line and dressed to ¼ inch. Joints shall be broken at least 15 inches on the face. The bottom bed shall always be the full size of the stone.

The granite starlings of Piers 4 and 5 shall have a smooth bush-hammered face. There shall be a draft line 3 inches wide around the lower edge of the belting course below the coping, and on the edge of the pointed starlings. The coping over the whole pier, and the small copings over the pointed starlings, shall have a smooth bush-hammered surface and face. All other parts of the work shall have a rough quarry face, with no projections exceeding 3 inches from the pitch lines of the joints.

The stones in the coping under the bearings of the trusses shall be at least 3 feet wide, and shall reach entirely across the pier. They shall have good beds for their entire size, and shall have a full bearing on large stones with dressed beds in the belting course below the coping.

The stones of the backing shall be of the same thickness as the face stones, and shall have dressed beds.

All stones shall be sound, free from seams or other defects, and shall be laid on their natural beds.

All stones shall be laid in full mortar beds. They shall be lowered on the bed of mortar, and brought to a bearing with a maul. No spalls will be allowed except in small vertical openings in the backing. Thin mortar joints will not be insisted on, but the joints shall be properly cleaned on the face and pointed in mild weather, the pointing to be driven in with a calking iron.

The face stones of each course in Piers 4 and 5 for a height of 26 feet, beginning about 3 feet below low water, shall be doweled into those of the course below with round dowels of 1⅛ inch iron, extending 6 inches into each course; the dowels shall be from 8 to 12 inches back from the face, and 6 inches on each side of every joint; the stones of the upper course shall be drilled through before setting, after which the drill hole shall be extended 6 inches into the lower course; a small quantity of mortar shall then be put into the hole, the dowel dropped in and driven home, and the hole filled with mortar and rammed. The two courses below the copings shall have the joints bound with cramps of ⅞ inch round iron, 20 inches long between shoulders, the ends sunk 3 inches into each stone.

The mortar will be composed of cement and clean coarse sand, satisfactory to the engineer, in proportions varying from one to three parts of sand to one of cement, as may be directed by the engineer for different parts of the work. When stone is laid in freezing weather, the contractor shall take such precautions to prevent the mortar's freezing as shall be satisfactory to the engineer. The stone shall be cut at the quarries.

No material shall be measured, or included in the estimate, which does not form a part of the permanent structure.

Any stone transported from the quarries and left over from the work will be the property of the bridge company.

APPENDIX B

Specifications for Superstructure—1882

(By Geo. S. Morison)

GENERAL DESCRIPTION

There will be three spans of through bridge, each 330 feet long between centers, divided into fifteen panels of 22 feet each, and two spans of deck bridge, each 110 feet long, divided into five panels.

In the through spans, the top chord, the end posts, the nine central panels of the bottom chord, the bolsters, rollers, and bearing plates, and all pins of every description, will be of steel; the other parts will be of wrought iron, except the pedestal castings and portal ornaments, which will be of cast iron. The deck spans will be entirely of wrought iron, except the pins, rollers, and bearing plates, which will be of steel, and the pedestal castings.

Each through span will contain approximately 492,000 pounds of wrought iron, and 288,000 pounds of steel, of which 78,000 pounds will be steel eye-bars. Each deck span will contain approximately 120,000 pounds of wrought iron.

PLANS

Full detail plans, showing all dimensions, will be furnished by the Chief Engineer of the Missouri Valley and Blair Railway and Bridge Company. The work shall be built in all respects according to these plans. No allowance will be made to the Contractor for any fittings of parts during erection, nor for any changes necessitated by errors in the plans when these errors could be discovered by inspection of the plans.

The dimensions given for rivets on plans are the diameter of the rivet before driving, the rivet holes to be 1/16 of an inch larger than this diameter.

MATERIALS

All materials shall be subject to inspection at all times during their manufacture, and the Engineer and his inspectors shall be allowed full access to any of the works in which any portion of materials are made. Timely notice shall be given to the Engineer, so that his inspectors may be on hand.

The steel shall be manufactured by the open hearth process; Bessemer steel will not be accepted. A small ingot shall be cast from every charge, and from this ingot a sample bar ¾ of an inch in diameter shall be rolled; if this bar fails to meet the requirements of the laboratory tests, the whole charge shall be rejected.

Steel used in the compression members, bols-

ters, bearing plates, pins, and rollers shall contain not less than 34/100 nor more than 42/100 of one per cent of carbon, and less than 1/10 of one per cent of phosphorus. A sample test bar ¾ of an inch in diameter shall bend 180 degrees around its own diameter without sign of crack or flaw. The same bar tested in a lever machine shall show an elastic limit of not less than 50,000 pounds, and an ultimate strength of not less than 80,000 pounds per square inch; it shall elongate at least 15 per cent in a length of 8 inches before breaking, and shall have a reduced area of 35 per cent at the point of fracture. It shall be incapable of tempering.

Steel for rivets and eye-bars shall contain not more than 25/100 of one per cent of carbon, and less than 1/10 of one per cent of phosphorus A sample bar ¾ of an inch in diameter shall bend 180 degrees and be set back upon itself without showing crack or flaw; when tested in a lever machine it shall have an elastic limit of not less than 40,000 pounds, and ultimate strength of not less than 70,000 pounds per square inch; it shall elongate at least 18 per cent in a length of 8 inches, and shall show a reduction of at least 45 per cent at the point of fracture. In full-sized bars this steel shall have an elastic limit of at least 35,000 pounds, and an ultimate strength of at least 65,000 pounds per square inch; it shall elongate 10 per cent before breaking, and for strains less than 30,000 pounds per square inch shall show a modulus of elasticity between 28,000,000 and 30,000,000 pounds.

Facilities for testing the sample bars shall be furnished by the Contractor at a point convenient to the steel works, and the tests shall be made at the expense of the Contractor and under the direction of the Chief Engineer.

The steel plates for the chords and the end posts shall be rolled in a universal mill.

Steel for pins shall not be hammered, but rolled between Gothic rolls.

The iron used in tension members shall be double-refined iron, rolled twice from the puddled bar. Small samples having a minimum length of 8 inches shall be furnished by the Contractor for testing as directed by the Engineer; these samples shall show an elastic limit of at least 26,000 pounds, and an ultimate strength of at least 50,000 pounds per square inch; shall elongate at least 15 per cent, and shall show a reduced area of at least 25 per cent at the point of fracture. The fracture shall be of uniform fibrous character, free from crystalline appearance. When tests are made of full-sized bars, a reduction of from 5 to 10 per cent, according to size of bar, from these requirements will be allowed, provided the iron is of uniform and fibrous character.

Small samples having a minimum length of 8 inches shall be furnished by the Contractor from the iron used in shapes, plates, and other miscellaneous forms, as directed by the Engineer; these samples shall show an elastic limit of at least 24,000 pounds, and an ultimate strength of at least 47,000 pounds per square inch; shall elongate at least 10 per cent before breaking, and show a reduction of area of at least 15 per cent at the point of fracture. In plates more than 30 inches wide an elongation of 8 per cent and a reduction of 12 per cent at the point of fracture will be considered satisfactory.

Cast iron shall be of the best quality of tough, gray iron.

RIVETED WORK

The riveted steel work used shall be punched with holes, not larger than 11/16 of an inch in diameter; the several parts of each member shall then be assembled, and the holes shall be reamed to 15/16 of an inch in diameter, at least 1/16 of an inch being taken out all around; the sharp edge of the reamed hole shall be trimmed so as to make a slight fillet under the rivet head, and the pieces shall be riveted together without taking apart. All rivets in steel members shall be of steel; they shall be of such size that they will fill the hole before driving, and, whenever possible, shall be driven by power. All bearing surfaces shall be truly faced. The chord pieces shall be fitted together in the shop, in lengths of at least five panels, and marked; when so fitted, there shall be no perceptible wind in the length laid out. The pin holes shall be bored truly, so as to be equally distant, parallel with one another and at right angles to the axis of the member.

All wrought iron work shall be punched accurately with holes 1/16 of an inch larger than the size of the rivet, and when put together a cold rivet shall pass through every hole without reaming. So far as possible, all rivets shall be driven by power. The holes for the rivets connecting the floor beams with the posts, and with the bolsters, which must be driven after erection, shall be accurately drilled to a templet; these holes shall be 1 inch in diameter, and the rivets 15/16 of an inch in diameter before driving. The pin holes in the vertical post shall be truly parallel with one another, and at right angles to the axis of the post.

Power riveters shall be direct acting machines worked by steam, hydraulic pressure, or compressed air, and capable of holding on to the rivet when the upsetting is completed. Cam riveters will not be allowed.

All plates, angles, and channels shall be carefully straightened before they are laid out; the rivet holes shall be carefully spaced in truly straight lines; the rivet heads shall be of hemispherical pattern, and the work shall be finished in a neat and workmanlike manner. Surfaces in contact shall be painted before they are put together.

FORGED WORK

The heads of iron eye-bars, and the enlarged ends of screws in laterals and counters shall be formed by upsetting, or by die-forging with a plate welded on the side; welds in the body of the bar will not be allowed. Six extra iron eye-bars, of such size as the Engineer shall direct, shall be furnished by the Contractor to be tested; these test bars shall meet the requirements above specified for strength of material, and at least four of them shall break in the body of the bar. Should these test bars fail to meet the requirements of the specifications, the whole lot of bars may be rejected.

The heads of steel eye-bars shall be formed by upsetting and forging into shape, or by such other process as may be accepted by the Engineer; no welds will be allowed. After the working is completed, the bars shall be annealed by heating them to a uniform dark red heat throughout their entire length, and allowing them to cool slowly. Four sample bars of sizes required in the work shall first be manufactured by the Contractor, and tested under the direction of the Engineer; these bars shall meet the requirements above specified, and at last three of them shall break in the body of the bar. If the tests of these four bars are satisfactory, the Contractor shall proceed with the manufacture of the full order of steel bars for the work, and from the bars so manufactured the inspector shall from time to time select six bars to be tested to breaking, which bars shall also conform to the requirements of the specifications. Should these test bars fail to meet the requirements of the specifications, the whole lot of bars may be rejected. All steel bars shall be tested to a strain of 20,000 pounds per square inch before shipment.

MACHINE WORK

The bearing surfaces in the top chord shall be truly faced. The ends of the stringers and of the floor beams shall be squared in a rotary facer. All surfaces so designated on the plans shall be planed.

All pins shall be accurately turned to a gauge, and shall be of full size throughout. The pin holes shall be bored to fit the pins, with a play not exceeding 1/50 of an inch. These clauses apply to all lateral connections, as well as to those of the main trusses. All pins shall be supplied with pilot nuts for use during erection.

All screws shall have a truncated V thread, United States standard sizes.

MISCELLANEOUS

All workmanship whether particularly specified or not, must be of the best kind now in use in first-class bridge work. Flaws, or surface imperfections, or irregular shapes, will be sufficient ground for the rejectin of material. Rough and irregularly finished work will not be accepted.

All iron and steel work shall be painted with one coat of Cleveland Iron-Clad Paint (purple brand) mixed with boiled linseed oil before it leaves the shop, excepting machine-finished bearing surfaces, which shall be coated with white lead and tallow.

PROPOSALS

Proposals will be received for the work in the following manner:

First. Material: Steel per pound; Wrought Iron per pound; Cast Iron per pound; the prices to include material and all patterns and other work of every description, delivered to the Chicago and Northwestern Railway on cars in Chicago.

Second. A single gross sum for the erection of the entire superstructure exclusive of the lower staging.

Third. A single gross sum for furnishing the lower staging for the entire work.

The right is reserved to accept any proposal for material delivered without erection or lower staging, or for material delivered and erected without lower staging. The lower staging will be understood to include everything below the floor timbers, on which the upper staging or the movable traveler will rest. Erection will include setting the wall plates, and drilling the necessary holes for the anchor bolts.

TIME

The entire material shall be rolled and delivered at the Contractor's shop on or before June 1st, 1883. The manufacture of the first span shall be completed on or before July 1st, 1883, that of the second span on or before August 1st, 1883, and that of the third span on or before September 1st, 1883.

No material shall be shipped until July 1st, 1883, unless by the express direction of the Chief Engineer.

The erection of the first long span shall be begun on or about August 1st, 1883, and the last span shall be erected, ready for the track, on or before November 1st, 1883.

TERMS

The Missouri Valley and Blair Railway and Bridge Company will pay for the transprtation of materials used in the bridge, from Chicago to the bridge site, and will secure to the Contractor the benefit of constructisn rates for tools and men.

Monthly estimates shall be made at the end of each month of the work done during that month. In these monthly estimates, the material delivered at the Contractor's shop, but not manufactured, shall be estimated at 60 per cent of the contract price for finished material in Chicago; manufactured material of uncompleted spans, at 80 per cent of the contract price for finished material in Chicago; and manufactured material for each entirely finished span at 90 per cent of the contract price for finished material in Chicago. Payments shall be made on or about the 15th day of the following month on these estimates, deducting from the amount of the same 10 per cent as security, to be held until the completion of the entire contract.

Estimates will not be made upon iron delivered and manufactured unless a proportionate amount of steel has also been delivered and manufactured.

Should the Contractor fail to establish his ability to manufacture steel eye-bars of the character required on or before April 1st, 1883, he will then be required to furnish iron eye-bars of about 40 per cent larger section, and proportionately larger steel pins, the dimensions and plans of which will be furnished by the Engineer, for the same aggregate price as he would have received for steel eye-bars and pins as shown upon plans.

No material will be paid for which does not form a part of the permanent structure.

If the tests of full-size eye-bars of iron and steel prove satisfactory, the expense of making these tests will be borne by the Missouri Valley and Blair Railway and Bridge Company; should these tests prove unsatisfactory, they will be charged to the Contractor. The expense of tests does not include the value of the eye-bars.

The contractor will be required, under a penalty of $150 a day, to have the work completed so that trains can be run across the bridge on November 15th, 1883, and the Contractor will receive a bonus of $100 for each day by which this date may be anticipated.

GEORGE S. MORISON.

November 1st, 1882.

APPENDIX C

TESTS OF FULL SIZE STEEL EYE-BARS

Summary of Results of Mechanical Tests Made at Watertown

Dimensions—Inches Length C. to C.	Width	Thickness	Elastic Limit Pounds Per Sq. Inch	Max. Load Pounds Per Sq. Inch	Reduction of Area Per Cent.	Extension Gauged Length Inches	Extension Per Cent	Modulus of Elasticity
172.12	6.52	1.02	34,890	69,250	44.2	120	12.2	30,456,000
180.80	6.52	1.38	33,670	66,700	45.0	120	22.0	28,846,000
180.92	6.52	1.54	34,470	69,920	42.1	120	16.6	29,702,000
264.00	6.52	1.14	32,570	64,740	46.6	200	20.0	29,498,000
295.05	6.03	1.02	24,550	52,390	18.7	....	... .	*28,089,000
300.18	7.02	1.49	24,280	45,270	17.5	200	7.9	28,776,000
263.96	6.50	1.03	36,270	....	....	....	....	†29,940,000
263.96	6.48	1.26	37,250	....	....	....	....	†30,120,000
264.00	6.50	1.26	34,680	64,750	45.9	200	16.5	30,627,000
263,97	6.53	1.40	35,230	64,020	43.9	200	20.7	30,030,000
263.96	6.53	1.39	37,440	70,470	37.9	200	13.1	29,585,000
264.00	6.52	1.52	32,690	....	....	....	....	‡30,030,000
263.94	6.50	1.02	37,250	67,630	43.1	200	15.0	*28,901,000
221.88	6.48	0.98	37,480	67,800	33.7	160	15.8	29,880,000
221.60	6.46	0.98	36,650	72,050	38.4	160	13.8	*30,270,000
262.70	6.46	0.98	37,600	68,720	34.1	200	12.3	29,630,000
261.85	6.46	0.96	35,810	65,850	39.2	200	12.0	29,960,000
262.12	6.45	0.97	33,230	64,410	49.5	200	16.4	29,670,000
261.72	6.46	0.97	37,640	68,290	42.4	200	13.9	29,960,000

* Bar Broke in Head. Retested.
† Bar Broke in Head. Not Retested.
‡ Bar Not Broken.

TECHNICAL PAPERS

JOURNAL OF THE

WESTERN SOCIETY OF ENGINEERS

Volume XXX MARCH, 1925 Number 3

The South Water Street Improvement

By Hugh E. Young*, M. W. S. E.

Presented December 8, 1924

Years of study by technical experts of the Chicago Plan Commission demonstrated the necessity of providing a means whereby through traffic could skirt the downtown district instead of going throught it. Thus the Chicago Plan Commission proposed a quadrangle of wide streets encircling the central business district to by-pass through traffic. This quadrangle is formed by Michigan Avenue, Roosevelt Road, Canal Street, and South Water Street. Michigan Avenue has been widened. The Roosevelt Road viaduct is being constructed under the jurisdiction of the Department of Public Works. The Canal Street widening is nearing completion. South Water Street, therefore, becomes the "keystone" of the entire plan.

Planning the Project

EVERY Chicago plan improvement can stand on its own feet, but all are so planned that each is a component part of the whole—one dovetails into the other. When the ten Chicago Plan street improvements now under way are completed, Chicago will awake to realize that conditions have been so improved that they will attract general attention and wonder.

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By its connection with Canal Street, the South Water Street improvement will form the northern boundary of a circuit of wide traffic arteries around the congested center, composed of South Water Street on the north, Canal Street on the west, Roosevelt Road on the south, and Michigan Avenue on the east. Not only will this quadrangle greatly relieve loop congestion, but the removal of South Water Street produce market to a more economical and better adapted location, will free traffic movement on the north-and-south and the east-and-west streets, and reduce the present congestion in the downtown district sixteen per cent.

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* Chief Engineer, Chicago Plan Commission.

MISCELLANEOUS

All workmanship whether particularly specified or not, must be of the best kind now in use in first-class bridge work. Flaws, or surface imperfections, or irregular shapes, will be sufficient ground for the rejectin of material. Rough and irregularly finished work will not be accepted.

All iron and steel work shall be painted with one coat of Cleveland Iron-Clad Paint (purple brand) mixed with boiled linseed oil before it leaves the shop, excepting machine-finished bearing surfaces, which shall be coated with white lead and tallow.

PROPOSALS

Proposals will be received for the work in the following manner:

First. Material: Steel per pound; Wrought Iron per pound; Cast Iron per pound; the prices to include material and all patterns and other work of every description, delivered to the Chicago and Northwestern Railway on cars in Chicago.

Second. A single gross sum for the erection of the entire superstructure exclusive of the lower staging.

Third. A single gross sum for furnishing the lower staging for the entire work.

The right is reserved to accept any proposal for material delivered without erection or lower staging, or for material delivered and erected without lower staging. The lower staging will be understood to include everything below the floor timbers, on which the upper staging or the movable traveler will rest. Erection will include setting the wall plates, and drilling the necessary holes for the anchor bolts.

TIME

The entire material shall be rolled and delivered at the Contractor's shop on or before June 1st, 1883. The manufacture of the first span shall be completed on or before July 1st, 1883, that of the second span on or before August 1st, 1883, and that of the third span on or before September 1st, 1883.

No material shall be shipped until July 1st, 1883, unless by the express direction of the Chief Engineer.

The erection of the first long span shall be begun on or about August 1st, 1883, and the last span shall be erected, ready for the track, on or before November 1st, 1883.

TERMS

The Missouri Valley and Blair Railway and Bridge Company will pay for the transprtation of materials used in the bridge, from Chicago to the bridge site, and will secure to the Contractor the benefit of constructisn rates for tools and men.

Monthly estimates shall be made at the end of each month of the work done during that month. In these monthly estimates, the material delivered at the Contractor's shop, but not manufactured, shall be estimated at 60 per cent of the contract price for finished material in Chicago; manufactured material of uncompleted spans, at 80 per cent of the contract price for finished material in Chicago; and manufactured material for each entirely finished span at 90 per cent of the contract price for finished material in Chicago. Payments shall be made on or about the 15th day of the following month on these estimates, deducting from the amount of the same 10 per cent as security, to be held until the completion of the entire contract.

Estimates will not be made upon iron delivered and manufactured unless a proportionate amount of steel has also been delivered and manufactured.

Should the Contractor fail to establish his ability to manufacture steel eye-bars of the character required on or before April 1st, 1883, he will then be required to furnish iron eye-bars of about 40 per cent larger section, and proportionately larger steel pins, the dimensions and plans of which will be furnished by the Engineer, for the same aggregate price as he would have received for steel eye-bars and pins as shown upon plans.

No material will be paid for which does not form a part of the permanent structure.

If the tests of full-size eye-bars of iron and steel prove satisfactory, the expense of making these tests will be borne by the Missouri Valley and Blair Railway and Bridge Company; should these tests prove unsatisfactory, they will be charged to the Contractor. The expense of tests does not include the value of the eye-bars.

The contractor will be required, under a penalty of $150 a day, to have the work completed so that trains can be run across the bridge on November 15th, 1883, and the Contractor will receive a bonus of $100 for each day by which this date may be anticipated.

GEORGE S. MORISON.

November 1st, 1882.

APPENDIX C

TESTS OF FULL SIZE STEEL EYE-BARS

Summary of Results of Mechanical Tests Made at Watertown

Dimensions—Inches Length C. to C.	Width	Thickness	Elastic Limit Pounds Per Sq. Inch	Max. Load Pounds Per Sq. Inch	Reduction of Area Per Cent.	Extension Gauged Length Inches	Extension Per Cent	Modulus of Elasticity
172.12	6.52	1.02	34,890	69,250	44.2	120	12.2	30,456,000
180.80	6.52	1.38	33,670	66,700	45.0	120	22.0	28,846,000
180.92	6.52	1.54	34,470	69,920	42.1	120	16.6	29,702,000
264.00	6.52	1.14	32,570	64,740	46.6	200	20.0	29,498,000
295.05	6.03	1.02	24,550	52,390	18.7	....	... .	*28,089,000
300.18	7.02	1.49	24,280	45,270	17.5	200	7.9	28,776,000
263.96	6.50	1.03	36,270	....	....	....	....	†29,940,000
263.96	6.48	1.26	37,250	....	....	....	....	†30,120,000
264.00	6.50	1.26	34,680	64,750	45.9	200	16.5	30,627,000
263,97	6.53	1.40	35,230	64,020	43.9	200	20.7	30,030,000
263.96	6.53	1.39	37,440	70,470	37.9	200	13.1	29,585,000
264.00	6.52	1.52	32,690	....	....	....	....	‡30,030,000
263.94	6.50	1.02	37,250	67,630	43.1	200	15.0	*28,901,000
221.88	6.48	0.98	37,480	67,800	33.7	160	15.8	29,880,000
221.60	6.46	0.98	36,650	72,050	38.4	160	13.8	*30,270,000
262.70	6.46	0.98	37,600	68,720	34.1	200	12.3	29,630,000
261.85	6.46	0.96	35,810	65,850	39.2	200	12.0	29,960,000
262.12	6.45	0.97	33,230	64,410	49.5	200	16.4	29,670,000
261.72	6.46	0.97	37,640	68,290	42.4	200	13.9	29,960,000

* Bar Broke in Head. Retested.
† Bar Broke in Head. Not Retested.
‡ Bar Not Broken.

TECHNICAL PAPERS

JOURNAL OF THE
WESTERN SOCIETY OF ENGINEERS

Volume XXX MARCH, 1925 Number 3

The South Water Street Improvement

By Hugh E. Young*, M. W. S. E.

Presented December 8, 1924

Years of study by technical experts of the Chicago Plan Commission demonstrated the necessity of providing a means whereby through traffic could skirt the downtown district instead of going throught it. Thus the Chicago Plan Commission proposed a quadrangle of wide streets encircling the central business district to by-pass through traffic. This quadrangle is formed by Michigan Avenue, Roosevelt Road, Canal Street, and South Water Street. Michigan Avenue has been widened. The Roosevelt Road viaduct is being constructed under the jurisdiction of the Department of Public Works. The Canal Street widening is nearing completion. South Water Street, therefore, becomes the "keystone" of the entire plan.

Planning the Project

EVERY Chicago plan improvement can stand on its own feet, but all are so planned that each is a component part of the whole—one dovetails into the other. When the ten Chicago Plan street improvements now under way are completed, Chicago will awake to realize that conditions have been so improved that they will attract general attention and wonder.

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By its connection with Canal Street, the South Water Street improvement will form the northern boundary of a circuit of wide traffic arteries around the congested center, composed of South Water Street on the north, Canal Street on the west, Roosevelt Road on the south, and Michigan Avenue on the east. Not only will this quadrangle greatly relieve loop congestion, but the removal of South Water Street produce market to a more economical and better adapted location, will free traffic movement on the north-and-south and the east-and-west streets, and reduce the present congestion in the downtown district sixteen per cent.

The district between Halsted Street and the river, Madison Street and Roosevelt Road, is near 27 freight yards and team tracks, but it is also of the greatest importance that it shall have the free and easy connection with the lake front terminals that will be provided by the lower level in South Water and River Streets. Such a connection will go a long way to enhancing the value of the west side terminal and warehouse district and of the property in that vicinity. Indeed, the South Water Street two-level improvement is absolutely essential to the proper development of this west side district.

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* Chief Engineer, Chicago Plan Commission.

sides via widened Canal and South Water Streets, without having to force its way through loop congestion. Traffic to and from the north, west and south sides using Milwaukee Avenue, Lake Street, Canal Street, the various west side streets and other thoroughfares, will be facilitated by the South Water Street improvement and the opening and extension of other streets that will be made possible by straightening the river.

Traffic to and from the south side will also find this a time saver, because it will be much easier, quicker and more convenient to go around the sides of the quadrangle than through the loop.

The South Water Street improvement will form the north boundary of the marginal traffic quadrangle enclosing the loop, the commercial clearing house for three million people, and the focus of a radial highway system extending throughout 200 miles of thickly settled territory.

Becomes Important Factor

Let us study why the two-level improvement will, when completed, become a most important factor in distributing traffic to and from the loop and in facilitating the movement of traffic througout the entire city.

The low level will have nine connections with the normal street system. It will have a six-lane freeway between Michigan Avenue and Lake Street and a 25-foot dock space for marine landing. Over one-half mile of "back-in" space for trucks will be provided along the south building line. The Illinois Tunnel freight stations, having a capacity of 1,000 tons per day, have been provided for with respect to space and access, one at the Wabash Avenue intersection and another on private property along the south side of the street between Franklin and Lake Streets.

Five thousand vehicle trips per day along Lake Street and Randolph Street now conflict with about three times this number in north-and-south streets. Most of this traffic can be handled by the low-level roadway of the new improvement. Freight originating on the West Side will reach the Illinois Central and Michigan Central yards over the Lake Street and Randolph Street bridges, thence through the western portals of the improvement at Market Street and at the foot of the ramp along the river from between Lake and Franklin Streets. Loop freight and South Side freight will enter the low level at Holden Court, Garland Court, Federal Street and Fork Street, the mid-block entrances from Lake Street. Traffic originating in the manufacturing district north of the river will cross the low level of the Michigan Avenue bridge and turn at the plaza into River Street, thence to South Water Street.

With the bulk of east-and-west traffic drawn through South Water Street, the congestion of Randolph, Lake and Kinzie Streets will be relieved; much to the advantage of these streets and all north-and-south streets which they intersect.

The low-level street will have a capacity of over 60,000 trucks per day. This trucking route will have no cross traffic. Commercial vehicles will flow uninterruptedly between the Illinois Central freight terminal area and the west side warehouse and the south side terminal district. A tremendous volume of business can take this by-pass around the loop, saving time and money to the industrial and commercial interest of Chicago.

The Upper-Level Street

A marginal drive as wide as the roadway on Michigan Avenue constructed at the level of the present bridges will be created, extending nearly three-quarters of a mile along the river. It will connect with every north-and-south street and also serve as a by-pass around the loop for through traffic between the north and west sides. It will function as a trunk distributor in that it will handle over 100,000 automobiles entering the loop from Michigan Avenue and La Salle Street, when the latter has been widened all the way to Lincoln Park. It will cause the removal of the produce market and take 16,000 market-vehicle trips per day off loop streets.

It will greatly facilitate commercial traffic on the important east-and-west

streets immediately south of the river by lessening cross traffic congestion. It will benefit State, Dearborn, Clark, Wells, and Franklin Streets by preventing the clogging, at present caused by peddler and grocery wagons between Lake and South Water Streets, which today occupy so large a proportion of these thoroughfares that only the street car tracks are available for through traffic, and even these are constantly blocked by market vehicles.

It will be a fine thoroughfare 110 feet wide, enjoying excellent light and transportation and inviting high-class commercial development.

The upper level has the advantages of a marginal circuit. Traffic will be able to distribute itself on the wide 72-ft. roadway and thus avoid turning in the congested street car thoroughfare.

Opens Direct Route

A direct route which will avoid business district congestion is opened from Michigan Avenue to the west side passenger terminals; to Washington Boulevard and to points beyond, via the improved and widened Canal Street. In this manner the east-and-west streets of the business district, particularly Jackson Boulevard will be offered relief.

Inasmuch as the present thoroughfare is entirely absorbed by private business, the creation of the upper and lower level thoroughfares in South Water Street and River Street will virtually give the city two great needed new east-and-west streets, by reclaiming for the public a street which it cannot use today, and by constructing beneath that street an entirely new artery for heavy traffic.

Bear in mind that one out of every four vehicles in the loop today is through-bound; that is, it does not stop anywhere within the loop. The completion of the quadrangle will reduce loop congestion 25%. This will be of direct and great benefit to the entire city, because approximately the same volume of traffic flows to and fro between the three sections.

Seven years ago traffic counts showed that the removal of the produce market would take 16,000 vehicle trips per day off loop streets. This meant a 16% reduction in loop traffic. Add to this 25% reduction that will result from the construction of the quadrangle in by-passing of automobile traffic between the north and west sides; in rerouting of the freight interchange between terminals; and in the terminal freight delivery to the low level of the new and improved South Water Street, and there will be a reduction of the loop congestion of over forty per cent. This means a tremendous relief from congestion and a tremendous saving in time and money.

In all probability there will be between 65,000 and 68,000 more automobiles upon our streets at the close of this year than there were on January 1st. Every Saturday night over one thousand automobiles have been added to the congestion on our city streets. Last year 263,329 vehicle licenses were issued in Chicago. Every day there are perhaps 100,000 vehicles from surrounding suburbs and elsewhere passing through Chicago. The continual building of good roads and the consequent increase in the use of the automobile means a continual increase in the number of out-of-town cars using our streets, particularly those in the downtown district.

Legal Features

Among the first difficulties to be overcome in making the designs and details for the South Water Street Improvement are the existing special assessment laws and the various court decisions. The drawings must conform to the laws. The land condemned by special assessment for street purposes must be used. The ordinance drawings must be made first, then the ordinances written, and an estimate made and approved by the Engineer for the Board of Local Improvements. After this has been done, these are presented to the Board of Local Improvements, a date for public hearing is set and the hearing is held. This meeting then sets a date for a second meeting and at that time changes can be made if so ordered by the Board. The Board then presents the ordinance and drawings to the City Council.

From this day forward there can be

no change whatsoever in either the drawings, estimate ordinances, or the specifications. They must stand or fall as they are at that date. The South Water Street case was in court over six months. During that entire period it was necessary to have one or more men assigned to the case to defend it against all comers.

The following information in regard to the legal features is presented through the courtesy of Mr. Wm. H. Dillon, former Assistant Corporation Counsel who was continuously in court defending the city's interests on this great improvement.

Two Classes of Improvements

"A local improvement is divided into two phases; First—the condemnation or street widening improvement, and Second—the street paving or street improvement. As to the first of these classes, the condemnation or street widening improvement, the law provides that before the City takes possession of any property it must pay for it in full in cash. Consequently the assessments for street widening must be paid in full in one installment, in order that the City may acquire the funds necessary to pay for the property to be taken. This is true both as to the assessment for benefits against private property and the assessment against the City on account of public benefits.

"As the second class; namely, street paving or street improvement, the legislature has provided (in Section 42 of the Local Improvement Act) that it shall be lawful to provide by ordinance that the assessment against each individual piece of property and the assessment against the City on account of public benefits may be divided into installments, not more than ten in number, excepting special assessments for building sewers, subways, or viaducts, which may be divided into installments not exceeding twenty in number. The first of these installments is due and payable on the second day of January next after the date of the first voucher issued on account of work done; the second installment one year thereafter, and so on annually until all installments are paid. The same section makes it obligatory upon the Board of Local Improvements to file in the office of the Clerk of the Court, in which said assessment was confirmed, a certificate signed by its secretary, giving the date of the first voucher issued to the contractor on account of work done and the amount thereof, which certificate shall be filed within thirty days after the issuance of said voucher.

City Issues Bonds

"The Local Improvement Act further provides (by section 73), that the contractor must look to the special assessment fund for his pay, and that he shall have no claim against the City except on account of said special assessment fund for such work; and it further provides (by section 86), that for the purpose of anticipating the collection of the second and succeeding installments, it shall be lawful for the City to issue bonds payable out of said installment, bearing interest at the rate not exceeding six per cent per annum, nor less than four per cent per annum. These bonds should not be confused with the street improvement bonds. Special assessment bonds are issued in practically every improvement which the City makes, no matter how small, and are redeemed out of the special assessment fund; while the street improvement bonds, which have been issued by the City in connection with the major improvements, are paid out of the general tax levy and are subject to the debt limitation hereinafter referred to. The special assessment bonds are not subject to such debt limitation.

"In the ordinary case the contractor has completed the work within a few months after the assessment is confirmed and the contract let, and as nearly every assessment is divided into five installments, running over a period of five years, and the contractor must look to the special assessment fund for his pay, it would be a hardship on the contractor to ask him to wait five years for his pay for the work which he has done. Therein lies the reason for the law permitting the issuance of bonds to

contractor is paid in these bonds, and anticipate the deferred installments. The the ordinary contractor sells them to some of the banking houses in Chicago who deal in this kind of papers at prices around 95. It might be pointed out that if there were some way to pay the contractor in cash, the cost of the improvement paid for by special assessments would be somewhat, if not considerably, lower than it now is.

"The public benefit and the overhead cost in the ordinary improvement is paid by the City out of its general coroporate fund, and in each year's appropriation bill there is an item for the payment of public benefits. But in the major street improvements such as Western Avenue, Ashland Avenue, Michigan Avenue, Robey Street, South Water Street, and Ogden Avenue, the cost of attorneys, engineers, witnesses, etc., is so heavy, and the public benefit chargeable against the city so large, that it would be impossible for the City to finance this cost out of its general corporate fund.

"Therefore some other way must be devised for financing these major improvements, and the remedy has been found by the City issuing its bonds payable over a long period of years. Out of the funds arising from the sale of these bonds the expenses to the City in connection with these major improvements are paid. The Constitution provides (Article 9, Section 12), that no city, county, town, etc., shall be allowed to become indebted in any manner to an amount in the aggregate exceeding five per cent on the value of the taxable property therein, this value to be ascertained by the last assessment for State and County taxes previous to the incurring of such indebtedness. Following this constitutional limitation the legislature, in the Cities and Villages Act (Cahills 1923 Statues, Chapter 24, Article 5, Section 65, Subdivision 5), gave the cities the power to borrow money on the credit of the corporation for corporate purposes and to issue bonds therefor, but it provided that no city shall become indebted in any manner or for any purpose to an amount in the aggregate to exceed five per cent of the value of the taxable property therein, to be ascertained by the last assessment for State and County taxes previous to the incurring of such indebtedness.

"Prior to 1919 Section 18 of the General Revenue Act of 1898 (Callaghan's Illinois Statutes Annotated, Chapter 120, Section 329), provided that personal property shall be valued at its fair cash value—which value shall be set down in one column to be headed **Full Value** and one-third part thereof shall be ascertained and set down in another column and shall be headed **Assessed Value.** Real property shall be valued at its fair cash value, which shall be set down in one column to be headed **Full Value** and one-third part thereof shall be set down in another column which shall be headed **Assessed Value.** And the Supreme Court in City v. Fishburn (189 Ill., 367), held, in interpreting the constitution and statutory provisions as to the limitation of indebtedness which a city might legally incur (Page 377):

Limit of Indebtedness

"'We think the constitution means that the limit of municipal indebtedness shall be computed upon and shall not exceed five per cent of the official estimate of the assessors for the preceding year as a basis for the apportionment of State and County taxes. That is, the amount which is set down in the column under the head of Assessed Value.'

"Therefore, while it is impossible for the legislature to pass any law which would make it possible for a city to become indebted in an amount exceeding in the aggregate five per cent on the value of the taxable property therein on account of the constitutional provision; nevertheless, by reason of the construction placed on this constitutional provision by the Supreme Court, it is possible for the legislature to pass a law increasing the valuation at which property is to be assessed and thereby increase the bonding power of cities in the State. This the legislature did in 1919, amending section 18 of the General Revenue Act of 1898 by providing that

one-half part instead of one-third part of the full value shall be ascertained and set down as the assessed value of real and personal property. It will be readily seen that even under the new provision the bonded indebtedness of Chicago is exceedingly small compared to the real value of the taxable property lying within its boundaries."

It was immediately after the amendment of 1919 that the street improvement bond funds for the major street improvements in Chicago were approved by the vote of the people and issued by the City of Chicago. The City has again reached the limit of its indebtedness, and there is now a great deal of talk about asking the next legislature to again increase the value at which property may be assessed, so as to thereby again increase the bonding power of the City and enable it to complete the improvements which it has started.

The last large bond issue for Chicago Plan improvements was on November 4, 1919, when $28,600,000 of bonds were voted for six street improvements. Of this amount $26,600,000 was specifically for West Side street improvements, and the balance of $2,000,000 was for Michigan Avenue—an improvement which no one can deny has been of great value and benefit to those who live on the West Side as well as the North and the South Sides of Chicago.

Bonded Debt Small

In this connection we should realize how Chicago's debt compares with that of other American Cities. There are 253 cities in the United States with a population of 30,000 or over. Of the 183 cities that reported financial statistics to the Federal Census Bureau in 1921, 131 had a per-capita debt larger than that of Chicago, and only 52 owed less money per inhabitant than Chicago owed.

Of the twelve largest cities in the United States three (Detroit, Cleveland and Baltimore) did not report their financial statistics to the Census Bureau. The remaining nine largest cities, arranged according to the size of their per capita debt, are:

1. New York	$182.93
2. Pittsburgh	107.91
3. Boston	107.29
4. San Francisco	96.75
5. Philadelphia	81.16
6. Los Angeles	75.03
7. Buffalo	70.58
8. Chicago	32.31
9. St. Louis	19.42

but since then St. Louis has increased its bonded indebtedness $112.88 per capita over and above this amount.

Economic Features

The South Water Street improvement is of the greatest possible importance. It will revolutionize street traffic and materially increase the value of property in the heart of the city and on the West, North and South Sides. It will increase the annual revenue of the City, and add to the assessed value of property, thus enlarging the city's bonding power. It will cut downtown street congestion nearly in half.

Economic conditions in Chicago, caused by congestion and lack of adequate street facilities, are inexpressibly bad and are constantly growing worse, to the detriment of the entire city. The remedy lies in carrying out with the greatest speed possible the major projects of the Chicago Plan.

Congestion Is Costly

Congestion in the central business district affects every individual in Chicago. The things we eat, the clothes we wear, every article we use costs more because of delays in transit, consequent loss of time, and increased cost due to downtown congestion. Our railroad terminals and our wholesale and retail houses are all grouped in and around the loop, and every article necessary to existence passes to and fro over our downtown streets before it reaches the consumer.

How congestion increases the cost of living is indicated by the fact that twelve years ago it was shown that the elimination of cross traffic on Michigan Avenue between Lake and Ohio Streets meant a saving of two million dollars a year. Think of what loop congestion adds to the cost of everything. There are 19 streets in the loop and 57 inter-

sections. The loop today is built up to only 50% of its ultimate capacity. Traffic increases at the rate of approximately 10% a year, yet already we call the congestion upon our loop streets intolerable. But that is fiction, for we do tolerate it.

During 1918 a study was made by the Plan Commission as to the excessive cost of handling the produce business on South Water Street. An independent study was made by the Federal Trade Commission a short time later. Both investigations showed that the loss to the people of Chicago, resulting from the existence of the produce market on South Water Street, at that time amounted to six million dollars a year. Since then increased costs make the resultant saving amount to double that sum, or twelve million dollars a year.

South Water and River Streets, so closely connected with Michigan Avenue as almost to form a continuation thereof, are undeniably destined to increase property values. The two improvements together will serve to add still further to values beyond what either improvement could possibly effect alone, not only along the line of improvements but on each side of the river, north, south and west, as well as in the downtown district.

Commission Spreads Assessment

In the matter of spreading assessments, the law requires the appointment of three court commissioners whose duty it is to determine the area to be specially assessed, and the specific amount each piece of property within that area is damaged or benefited by the improvement.

Their findings must be sustained before the court, and the law provides ample safeguards, so that no property owners can be made to pay one dollar more than the City can prove his property will be benefited. Thus every property owner whose property is taken or damaged is assured just treatment and receives fair compensation.

The property that fronts upon the improvement naturally pays the largest assessment, the amount becoming smaller and smaller the farther away a piece of property is from the line of the improvement. In view of the increased value of property that will result, it is plain that no real burden will be caused by the special assessments, but, on the contrary, a very great benefit will result.

When the improvement was first suggested, it was estimated that it could have been made for approximately $7,000,000. However, this did not include the widening between State Street and Michigan Avenue along South Water and River Streets, the construction of the upper level of South Water Street between Wabash and Michigan Avenues, and the supplemental connection with the lower level emerging in Market Street between Lake and Randolph Streets; all of which were later included in the improvement, and which increased the estimated cost of construction to approximately twelve million dollars. Not until the Michigan Avenue improvement was finished was the necessity sufficiently realized of making the South Water Street Improvement complete by the inclusion of these new features.

Since then, the increased value of South Water and River Street Property, due to the Michigan Avenue Improvement, and the increased cost of labor and materials, have brought the present estimated cost up to twenty-four million dollars.

New Market

Of the firms that have moved away from South Water Street on account of construction or in anticipation of the new improvement, the poultry interests have located in Fulton Street at the Fulton Market. Others have located on Randolph Street. Property values in that district have increased several hundred percent, as a result, and for the further reason that Randolph Street has been widened, and Ogden Avenue has been opened as a great northeast and southwest artery between the north and west sides, connecting with Randolph Street at Union Park.

Of those remaining on South Water Street, several have stated their intention of going to the Randolph Street Market on the West Side.

The major interests on the street, however, have divided into two groups. One—the store group, representing the largest number, has obtained options for the purpose of relocating the South Water Street Market in the vicinity of 16th Street and Morgan Street. A market in this location will require vehicle transport between the retail site and storage facilities.

The second group, representing the wholesale dealers, who sell car load lots, are securing options on property in the vicinity of Ashland Avenue and 31st Street. A market in this location will have team track service as well as office space and storage facilities.

Design and Construction Features

By T. A. Evans*

Presented December 8, 1924

General features of the design and construction of the South Water Street Improvement are given in the following paper by the engineer who had charge of the design. Many of the less important details are not fully described as it would have required a small book to include all of them. Editor.

In beginning the designing of the South Water Street Improvement it was first necessary to determine the elevations of the lower and upper levels of the proposed thoroughfare. Lake Michigan has a rise of approximately 3 feet above and a fall of approximately 2 feet below Chicago City Datum over a cycle of about seven years. Allowing for the ordinary waves and wind action on the river, it was decided that the dock should be built at an elevation of plus 5 above Chicago City Datum. Once having determined the lower elevation, it was comparatively easy to determine the approximate elevation of the upper level.

A minimum overhead clearance of 12 ft. 4 in. has been provided throughout the entire improvement. The thickness of the deck slab varies considerably, depending upon the column spacing. Taking an average thickness of about 16½ in. and adding to this the thickness of the asphalt pavement of 4 in. allowing for the drop panels and the crowning of the lower level pavement, it is found that the height of the upper roadway will be approximately plus 20 ft., this being the average from State Street to Franklin Street and was about the maximum elevation that could be worked in the State Street Bridge and about the minimum elevation that would accommodate the elevations of the new bridges, such as Wells Street and Franklin Street without objectionable changes to the grades.

The new bridges across the Chicago River have been built in such a manner that they have a clearance over the water of 16 ft. 6 in. for 80% of their respective spans. The lower level roadway of the Michigan Avenue bridge is approximately at the same elevation as the present State Street bridge and the upper level of the South Water Street Improvement connects with the present State Street bridge and to the upper level of Michigan Avenue bridge and not to the lower level. This required a large number of layouts of the roadways for the upper thoroughfare in order to provide grades that would not be noticeable for traffic passing from State Street northeast along River Street to Michigan Avenue or coming north on Wabash Avenue going up River Street connecting to Michigan Avenue, and at the same time would permit a new bridge to be built in line with Wabash Avenue connecting to Cass Street or State Street on the north side of the river and would also permit further connection to be made from the lower level of Michigan Avenue bridge to the upper level of South Water Street Improvement by means of a ramp on the river front. This ramp will connect with the upper level north of the future bridge abutment at Wabash Avenue in case the same is ever built.

Opposite the intersection of River Street, East South Water Street and Wa-

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bash Avenue a large safety island is to be placed in the center of the roadway. This safety island will serve a dual purpose. It will act as a refuge for pedestrians and permit the grades on the two roadways to be at different elevations, thus permitting the Wabash Avenue and East South Water Street intersection to be somewhat flattened with the gradual rise on the roadway from West South Water Street and Wabash Avenue to the junction of River Street and Wabash Avenue.

The elevation at Michigan Avenue is plus 13.45. The elevation at the east side of State Street is plus 20.5. The elevation at the intersection of Wabash Avenue and South Water Street is plus 24.46. The gradient on East South Water Street to State Street is 1.2% and the gradient on East South Water Street connecting to River Street is 1.39%, whereas the gradient on the north side of the large safety island, just referred to is 1.86% and the gradient from the present Dock Street to Michigan Avenue is approximately 1.81%. The elevation of East South Water Street and Michigan Avenue is plus 27.0 with a descending grade of .68% from Michigan Avenue to Wabash Avenue.

No Sharp Grades

Although these various connections to the upper level coming from different directions and at different gradients were the cause of considerable trouble on layouts, the grades on the final plans, we believe, will be of such a nature that high speed traffic can travel over the same without being jolted or discommoded. The problem was considerably simplified by the use of contour lines.

The problems on the upper level were simple in comparison with the difficulty of arranging the grades and column spacing for the lower level. The first problem encountered was the division of traffic at River Street and Michigan Avenue on the lower level. This being a flat slab structure it was absolutely necessary that the column spacing be limited to a maximum distance, center to center, of approximately 44 ft. These figures were arrived at arbitrarily and have since been found to be approximately correct as we are limited in thickness allowed on this particular improvement by the elevations and grades required on the upper level and the headroom required for the lower level roadways.

In laying out curves at points of intersection it was found that cars and trucks could turn around a circular island whose diameter is 40 ft. We therefore took 20 ft. as a minimum turning radius for automobiles and the curvatures were so arranged as to allow for the lagging of the rear wheels. Ordinary cars in turning a very sharp curve require 9½ ft. in width whereas on straight runways they require 6½ ft. and lines of traffic were laid out on paper giving the required clearance for the two or three lines of vehicles as the case might be. This meant that at the curves the thoroughfares of necessity were wider than on the straight runways.

Has Three Roadways

In making the designs for East South Water Street we found it was impractical to place three rows of columns in the street, one at each curb and one in the center of the street, and that by thickening the slabs slightly we could use two rows of columns, one at each curb and make the street free of obstructions. This made a substantial reduction in the total cost and gave a much more desirable thoroughfare. The standard section from State Street to Franklin Street as adopted consists of four rows of columns making three roadways. Two roadways will be for through traffic, the north one, adjacent to the river, being for westbound traffic and the central one for eastbound traffic. The south roadway will be reserved for vehicles making use of the loading platform. This caused an offset at Wabash Avenue of approximately 42 ft. to the north. It is also quite probable that Wabash Avenue may be extended to the south as a double deck structure some time in the future and these thoroughfares as designed are all provided for without obstacles.

From State Street west to Franklin street the problems were all of a minor nature with the exception that provisions must be made at all street intersections

for future subways and it was necessary to span these intersections by means of large underground girders supported on caissons beyond the area that might be occupied by subways, while the loadings at the street intersections were considerably heavier than the loading at other portions of the improvement. This is caused by the street cars at these particular points.

The pavement at the street intersections on the upper level is granite blocks 4 in. thick resting on a 1-in. sand cushion but at the street car tracks the distance from the top of rail to the bottom of the steel ties is 15 in. and this makes an average increase in the depth of slab of 11 in. in addition to the thickness required by the heavy loads at these points. In order to provide for this increase in depth of slabs we raised the street intersections 3 in. on the upper level and dropped the lower level the balance of the distance as the lower level at this point is protected from the water by the bridge abutment on the river front.

At the LaSalle Street intersection the layouts provided for the future LaSalle Street bridge and placing the caissons at this point involved no extraordinary difficulty as the same procedure was followed at this point as at the other streets and the existing subway does not increase the difficulty.

Sub-Girders Span Tunnels

Considerable difficulty was encountered at Wells Street as we endeavored to use existing caissons under the present bridge abutment and it was necessary to use cantilever girders beneath the lower level roadway as there is a freight tunnel running east and west underneath the second row of columns from the street supporting the superstructure. At this point we also had the additional problem of supporting the elevated railroad structure. We found that it could not be supported on the upper slab and this required changes to the existing elevated structure and re-spacing of the columns, placing the north columns in line with the supporting columns for the flat slab and the south columns on the sidewalk on the south side of the street carrying the elevated structure across South Water Street by means of two lattice girders.

At the Franklin Street intersection we made no provision for a future subway. The angle made by South Water Street and Franklin street at this point on the upper level caused a very peculiar spacing of columns, in fact it was impossible to use flat slab design at this point and we resorted to beam and girder construction.

Lake Street intersection involved no serious problems for spacing of columns and piers but did involve serious problems in designing the flat slab as we found it impossible to raise the upper level more than 4 in. It certainly is not feasible to drop the lower level below high water. Being limited by two given elevations we found it necessary to use a highly reinforced flat slab.

Use Flat Slab

The superstructure is planned for a flat slab construction with four-way reinforcing except at some few odd points where the panels are triangular or the spans are excessive in length. The triangular panels are designed as beam-and-slab construction by extending the drop panels or portions of the drop panels from column to column.

The city ordinances have been followed in regard to the minimum thickness of slab and minimum drop panels, diameters of columns, column caps, etc. Where it became necessary because of excessive loads these slabs were thickened. The columns are octagonal in shape and 34 in. outside diameter. The capitals are 7 ft. 4 in. outside diameter.

These columns are exposed to traffic conditions that are comparable with the columns of the elevated railway structure in the loop district. The overhanging ledges of trucks will undoubtedly knock the columns at a good many different elevations depending upon the loads being carried. There will also be bumps occurring by the turning and backing up of vehicles due to the overhang of the truck body in the rear. From numerous measurements made on all types of vehicles we decided to protect the columns with metal hub guards, 6 ft. 3 in. high, octagonal in form, the outside face of the

same to be flush with the outside faces of the columns. Above the pavement at the foot of the columns are placed cast-iron wheel guards extending into the roadway a distance approximately 9 in. and projecting above the roadway a distance of 1 ft.

Columns Protected

A mastic joint is placed around the columns protecting them from shocks from the lower level pavement and from the wheel guards. The mastic joint also permits a slight motion of the columns and reduces the bending in the columns from the expansion and contraction of the upper-level slab. The wheel guards after being placed in position are filled with concrete in order to make them stable and solid.

The balustrade on the north side including the coping on the north edge is made of Bedford stone. The balance of the structure with the exception of the small corbel over the column is concrete. At the base of the outer column facing the river is a piece of granite inset into the concrete extending approximately a foot above the tops of the wheel guards. The elevation of the pavement at the bottom of the wheel guards varies considerably but the elevation of the top of the granite is one straight line for the entire length of the improvement and is at an elevation of plus 7.42 ft.

The lower-level roadway rises from the dock at plus 5.0 on the south to a maximum elevation of plus 5.4 for the typical section about midway between the two outer rows of columns. This has been done in order to provide drainage in bad storms especially when the wind is from the north and has a tendency to blow the water underneath the structure.

The gutter on the lower-level roadway occurs just south of the second row of columns. This leaves the two through-traffic lanes free of all minor undulations that are usually placed in streets for catch basins, inlets, etc. and the gutter is so placed that the trucks when backed up to the loading platform will have their front wheels free from the same. The loading platform on the south side of the street performs a double duty. It is used as a sidewalk and loading platform for trucks, and also it is a part of the ventilating duct. The oak bumper on the upper edge is placed at a height of 3 ft. 3½ in. above the pavement. This has been found to be about the best average height for loading purposes. The oak bumper is anchored to the concrete platform by means of through bolts. The upper edge is protected by means of a checker plate that extends beyond the front face a distance of 2½ in. and extends back of the rear face a distance of about 3 in. into a slight recess in the concrete making the top of the checker plate flush with the top of the concrete. This will avoid the usual wear that occurs along the face of oak bumpers and at the same time furnish a grip for some one that might slip and thus prevent his falling to the pavement below.

Use Forced Ventilation

On the upper face of this ventilation duct are placed manholes at convenient distances for the entrance into and the cleaning out of the ventilation ducts. On the front vertical face right opposite the exhaust of motor vehicles are placed the openings to the ventilation system. These openings are adjusted by means of a key from the outside which prevents mischievous individuals from opening or closing the same without a key.

Over this combined sidewalk loading platform and ventilation duct are placed a series of sidewalk lights in the upper level about 1 ft. 3 in. from the face of the building extending out from the slab a distance of 4 ft. 9 in. These lights are exposed directly to the sky from the vertical face of the building to the tops of the buildings on the opposite side of the river and will thus permit a considerable amount of direct light to be thrown into the lower level. The lower level will have the lamp reflectors set into the inclined column capitals in such a manner as to throw light along the line of travel. The faces of these boxes will be practically flush with the surface of the concrete. All structures have been placed ½ in. away from the property lines. This is done in order to prevent interference with the various buildings that may be slightly irregular on the front face. The apex of

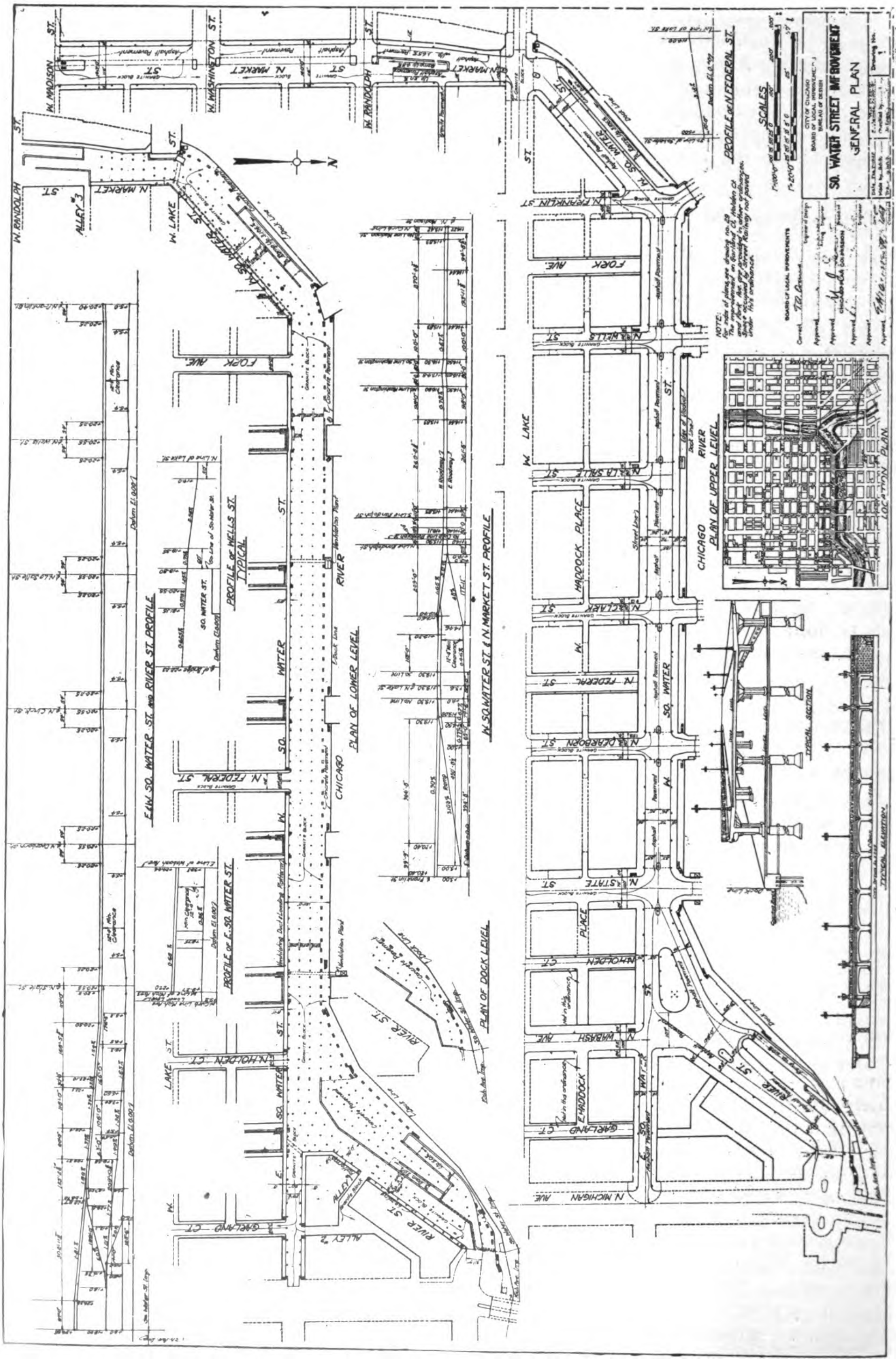


FIG. 1. GENERAL PLAN OF SOUTH WATER STREET IMPROVEMENT

the upper roadway is 9 ft. north of the center line. This is caused by having the north gutter 6 in. higher than the south gutter. The street is tilted in order to prevent undulations at the bridges as all the south bridge approaches rise to the north across South Water Street and it also assists us in giving the desired headroom over the high point on the lower level pavement which occurs between the two north rows of columns.

In a part of the two level structure on Market Street south of Lake Street steel construction will be used on the supposition that the improvement may be extended farther south at some future time, in which case it will be necessary to remove this section and rebuild it at a different grade.

Liberal Expansion Joint

Double columns have been provided at all expansion joints and have been extended below the lower level a sufficient distance to give them some elasticity. This is done in order to provide for expansion as the upper ends of the columns are rigidly attached to the flat slab and the lower ends of the two columns at the expansion joints are rigidly fastened to the top of the same pier. The lengths of these columns are as a rule approximately 29 ft. It would have been quite proper to make the end columns slender but the City Code requires that the diameter of a column be made more than one-twelfth of its clear height and also, more than one-twelfth of the length of the floor panel it supports. In order to keep uniformity throughout the entire improvement it was decided to keep all columns of the same diameter. The panel lengths determined the diameter of our columns. At all street intersections expansion joints have been provided at opproximately 16 ft. east of, and west of, the respective property lines projected north from the south and there are also east and west expansion joints, one just north of the north row of columns and one at the south property line of South Water Street. This keeps the intersections independent of the straight stretches of the improvement. In the section between State Street and Franklin Street in addition to the expansion joints just mentioned 16 ft. east and west of the respective street lines, there is one at the center of each block. This reduces the amount of expansion that takes place at any particular expansion joint and thus eliminates some of the troubles that usually occur at expansion joints. The expansion joints in the roadway are steel plates rigidly attached to one slab and free to move in the slot in the concrete in the other slab, mastic being placed in this slot. Over the entire joint is rolled a regular asphalt pavement. At a distance of approximately 6 in. below this plate a copper drip has been placed and condensation or leakage that may occur at this point will be carried over to the adjacent column. The curb expansion joints are just plain overlapping cast iron plates firmly anchored to the respective curbs. The expansion joint in the sidewalk consists of a copper plate placed about 2 in. below the surface of the sidewalk and the entire space on the sidewalk is filled with soft asphaltic mastic. Downspouts and gutters are placed at convenient points along the curb and are in all cases carried down on the outside of the column cap and adjacent to the column. The appearance of the structure could have been improved by running the downspouts inside the columns but we were afraid that the columns might be damaged by freezing.

General Plan

Fig. 1 is a general plan of the South Water Street Improvement. The lower plan indicates connecting roadways on both the upper and lower levels and shows an outline of the sidewalks and roadways on the upper level. The upper plan indicates the locations of the columns supporting the superstructure and the connecting streets and ramps, and the profile of East South Water Street and River Street is given on the upper portion of the drawing with a profile of West South Water Street and Market Street in the center. Automobiles crossing Michigan Avenue bridge on the lower level going south and turning west on River Street will follow the path between the third and fourth rows of columns turning approximately opposite the Wabash avenue front, passing to the west be-

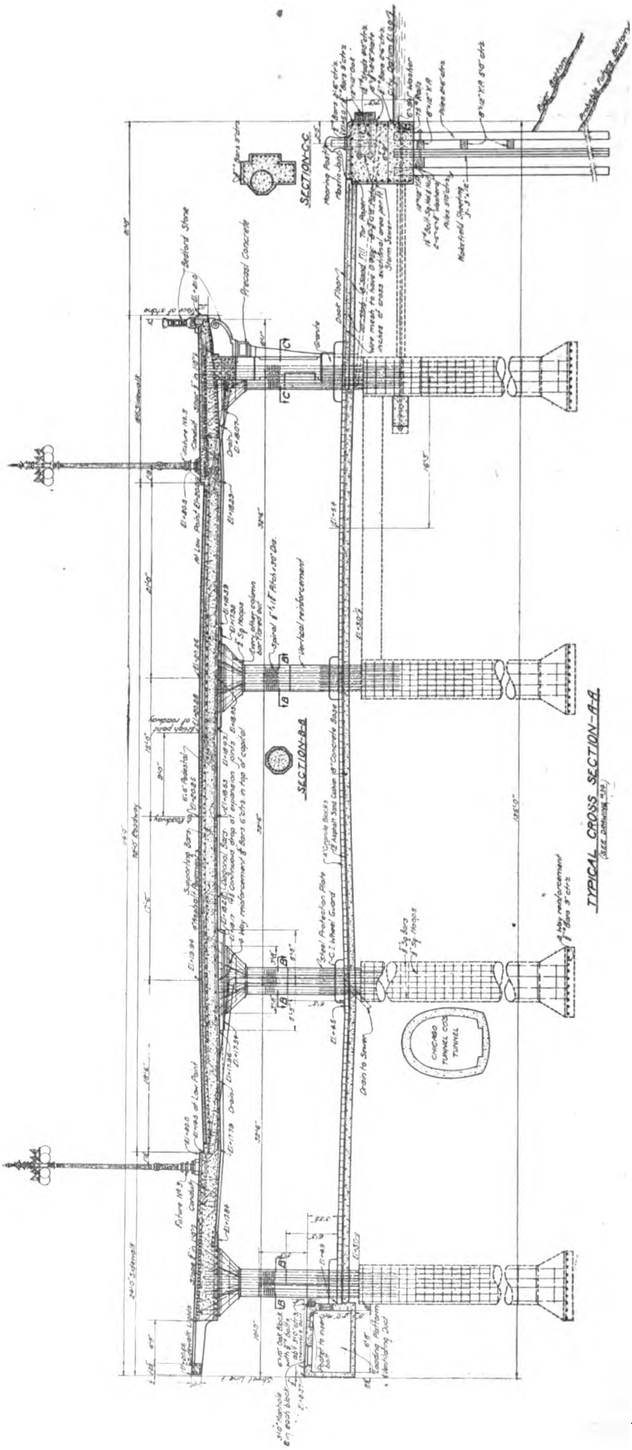


FIG. 2. TYPICAL CROSS SECTION—STATE STREET TO FRANKLIN STREET.

tween the two north rows of columns and west on West South Water Street to Lake Street between the third and fourth rows of columns, then turning into the common ramp and reaching the upper level of Randolph Street. Automobiles going north on Market Street can enter the lower level at Randolph Street by means of the ramp and will pass along the thoroughfare immediately south of the one just indicated arriving at Michigan Avenue either at East South Water Street, or by turning northeast and going between the second and third rows of columns on River Street.

The streets connecting to the lower level of South Water Street are four in number and cut the present Haddock Place into five sections. It was found impossible to connect Wabash Avenue to North Holden Court, North Holden Court to State Street, Dearborn or Clark Street to Federal Street, Wells or Franklin Streets to Fork Avenue by means of Haddock Place as the intervening distance was too short for the differences in elevations. For example, Dearborn Street rises to the upper level and Federal Street descends to the lower level and they are at the same elevation at Lake Street. If they had been connected, the grades would have been over 7%.

Pavements

The pavements on the upper level will be asphalt, except at intersections where street cars cross. At these points the pavements will be 4-in. granite blocks placed on 1-in. sand. This pavement will extend from street line to street line for the north and south streets. The pavements on all approach streets will be 5 in. granite blocks on 1-in. sand over a concrete base 8 in. thick. The pavement on the ramps will be concrete block and the pavement on the entire lower level will be granite block except from the center line of the north row of columns to the dock. This will be a 10-in. reinforced concrete slab. This, in general, covers the pavements with the exception of Market Street from Lake Street to Randolph which is asphalt except for a small portion on the east side at Randolph Street which is granite block.

Market Street from Madison Street to Randolph Street will be widened. The street will be made 24 ft. wider by cutting 12 ft. off of the present east and west sidewalks. The east roadway will have a minimum width of 42 ft. and will be paved with 5-in. granite blocks. The west roadway will have a minimum width of 38 ft. and will be paved with asphalt between street intersections. The space beneath the elevated railroad will be paved with 5-in. granite blocks.

Madison Street, Randolph Street and Washington Street grades will not be changed.

The crown of the new pavement will be about 35 ft. east of the present west property line. The present undulations in Market Street will be partially removed.

Fig. 2 is a typical cross section of the improvement from State Street to Franklin Street. The south row of columns is 10 ft. from the building line and the rows of columns are all spaced equally at 32-ft., 6-in. centers, the overhang on the north side being 6 ft. 6 in. In this section you will note that the sub-piers are shown reinforced as it was impossible to foretell just what would happen in case a property owner should make excavations to the building line through the upper stratum in which the material is a soft clay and has a tendency to settle in case the adjacent support is released. This would place considerable side pressure on the sub-piers adjacent to the excavation. The minimum diameter of these piers is 4 ft. 3 in., which means they would also act as retaining walls by resisting the horizontal movement of the earth. They have been figured to take a horizontal earth presssure for a distance of approximately 26 ft. below the lower level.

The dock is supported on two rows of piles with a row of Wakefield sheeting between. The north row of piles is spaced 2 ft. 6 in. and the south row 5 ft. center to center. The Wakefield sheeting is 9 in. thick.

The piers adjacent to the river are reinforced to withstand the earth pressure against the sheeting of the dock. The dock ties are held in position by horizontal girders placed back of the north row of piers and are not in any case anchored

to the piers themselves. The object in having the ties separate from the piers was to prevent cracking of the columns, superstructure or piers in case the dock was rammed by a large vessel. About the only damage the vessel could do would be to shatter the tie and push the rod through the supporting girder back of the pier, the rods themselves being encased in asphaltum where they pass through the rear girders. The anchors to the dock consist of horizontal rails placed along the front row of piles. The dock floor is a 10-in. concrete slab reinforced with wire mesh and rests on the rear edge of the dock but is free from the dock and the columns, there being a mastic joint around each connection. The 12x12-in. oak wale pieces are anchored to the dock wall by means of bolts screwed into turn buckles, the face of the turn buckles being flush with the outside face of the dock. The heads of the bolts are placed in cup washers, thus leaving the face of the wale piece smooth. The turn buckles are anchored in turn by bolts to the rear end extending into the concrete and looped.

At the top and bottom of the column capital we have placed mouldings. This was done in order to conceal the shrinkage effect of the shaft at its junction with the column capital and the top of the column capital to the drop panel.

Provision for Bending Stresses

The most difficult problem encountered in the design of the columns was the provision for the bending stresses caused by the expansion and contraction of the upper level slab. In order to keep these stresses within reasonable limits the columns will extend through the lower level pavement to various depths depending upon the distance from the center of expansion.

The lower level pavement will be kept two inches away from the columns and the space will be filled with a soft mastic so that the deflection of the columns will not be interfered with by the pavement.

The outer row of piers is tied to the second row by means of concrete ties in order to make a more equal distribution of dock pressure over the structure.

The piers are to be carried down to hardpan. The footings will be tested by means of borings into the material at all points in order to determine the thickness of the underlying stratum of hardpan. If the hardpan is found to be less than 7 ft. thick the borings will be continued 8 ft. farther to determine whether it is necessary to carry the footing to a greater depth, as we do not consider a stratum of hardpan of less than 7 ft. as being of sufficient thickness unless the underlying strata are of such a nature that they will not flow.

The maximum allowable load in the hardpan has been taken as 7 tons per sq. ft.

Founded on Hardpan

The reason for this is that in the area where South Water Street is to be built we have a stratum of soft clay 40 ft. or more in depth. This being somewhat elastic in nature may settle at any future date in case the abutting property owners should decide to build basements extending down to and connecting to the present freight tunnels in South Water Street or future subways in the north and south streets, in which case there would be settlement of the south row of piers if they are not carried to a firm foundation. This settling of the clay will, by means of friction, certainly place heavy loads on the footings of the piers. The same also holds true at street intersections where future subways may be built.

Sub cross-girders have been provided beneath the lower level roadway to carry the columns that are over the subways or freight tunnels. The largest of these is at Lake Street and is 48 ft. center to center of supports, 10 ft. 6 in. deep and 5 ft. 8 in. wide. It carries a concentrated load at the middle of 622,000 lb. The tension steel consists of 39 bars 1½ in. square or 87.75 sq. in.

Provisions have been made for utilities running east and west in the bay between the first and second rows of columns. There is also a space allowed for a future sewer to be built by the Sanitary District, the approximate outside dimensions of which will be 10 ft. x 10 ft.

Provisions are made also for the ventilation ducts that will lead from the south side of the street to the north side of the street connecting to the ventilating stations.

Loading

The loading and the unit stresses used in the design of the structure are the sames as those used in the design of Chicago River bridges. As previously explained, the structure is divided by expansion joints into sections approximately one hundred fifty feet long. Each of these sections was considered as a continuous rigidly connected structure and each column is assumed to be fixed at the top of the cylindrical pier on which it will be supported. Temperature stresses have been provided for on the assumption that there may be a change of 60 degrees from the temperature at which the structure is built. At a few places near the east end, where the structure has three levels, with the lowest section of the columns very short it was found impracticable to use concrete columns on account of the great bending stresses produced by the changes in temperature, and steel columns will be used in those places.

The slope deflection method was used in calculating the stresses.

Market Street Approach

On Market Street from Lake Street to Randolph Street, the two-level structure continues about half way to Randolph Street. From there the upper level is graded down to meet the present level of Randolph Street. The lower level is brought up to the level of Randolph Street by a ramp in the middle of Market Street thus leaving a roadway in Market Street on each side of the ramp. The west roadway will be used by high speed or boulevard traffic, both north bound and south bound and the east roadway will provide for heavy traffic, also in both directions. These two roadways will continue to Madison Street. At the end of the ramp there will be a large "safety island" compelling vehicles leaving the lower level to turn into the east roadway and providing protection for pedestrians going east or west on Randolph Street. There will also be a safety island at the middle of Market Street in line with the sidewalk on the south side of Randolph Street on each side of Washington Street and on the north side of Madison Street. It may also be mentioned that the elevated railroad structure forms a substantial separation between the two roadways from Lake Street to Madison Street.

The combined ventilation duct and loading platform is continued along the east side of Market Street and there is a loading platform along the west side. There is ample space for trucks to line up along these platforms without obstructing the traffic.

Franklin Street to Lake Street

This section is very much like that already described with the exception that there is a ramp along the river front by which traffic can pass from one level to the other. This is known as Contract Section No. 3 and is now under construction. The buildings along the river front of this section have all been wrecked and much of the debris has been cleared away. The excavation for ten of the cylindrical piers has been practically completed. Test loads are now being applied and concreting will begin soon. The soil conditions are so far just about what was anticipated, namely a few feet of filled in earth and rubbish, then soft clay gradually increasing in hardness until hardpan was struck about minus 75. No trouble from water has been experienced and no pumping has been necessary. The borings in the bottom of the holes have shown the layer of hard pan to be less than 3 ft. thick and as yet these borings have not been carried much deeper than this.

Every effort is being made to complete the work at Franklin Street so that the Franklin Street bridge can be restored to use at the earliest possible moment. This contract is now about two months ahead of schedule.

Fig. 3 is a plan and elevation of the east property line from North Dearborn Street to the east property line of North State Street. The upper view is a plan of the upper level. The middle of the sketch is an elevation of the improvement as seen from the north. The lower sketch

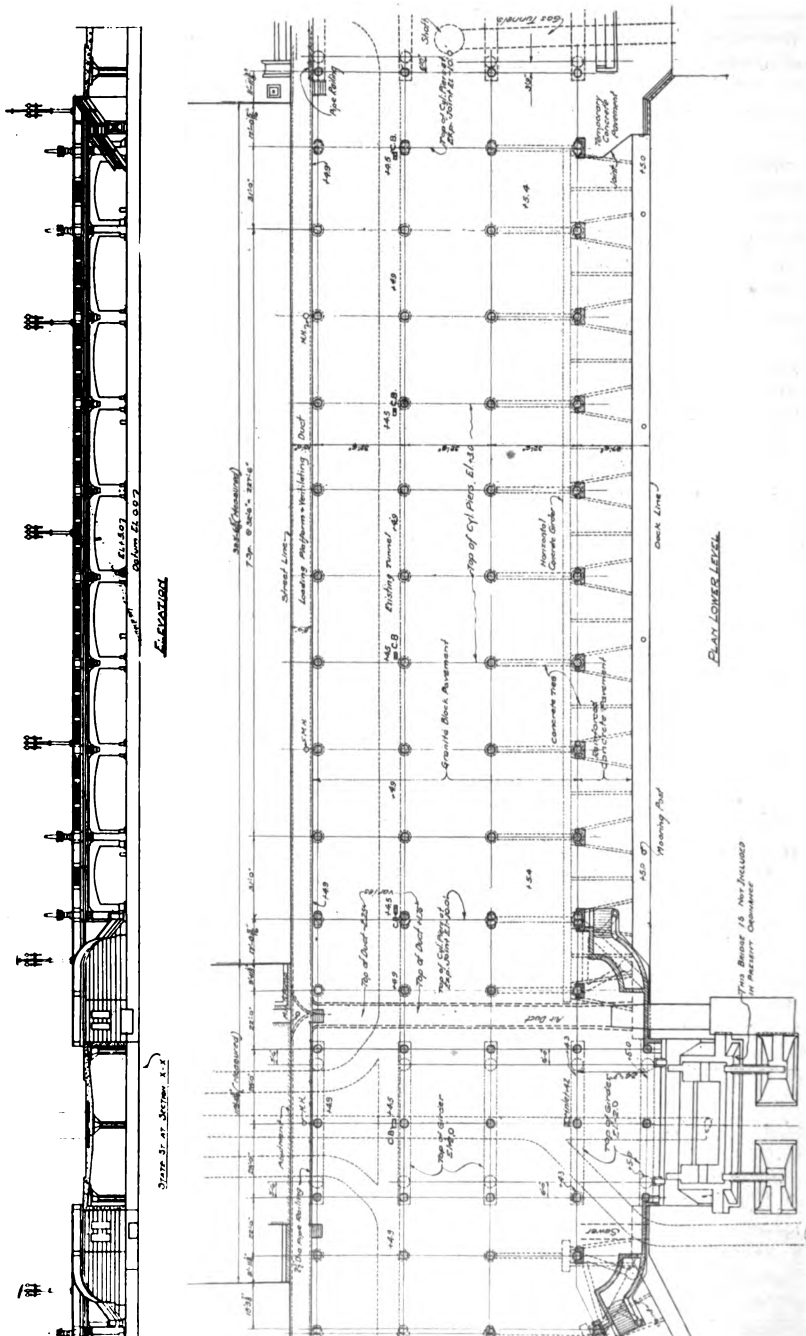


FIG. 3. ELEVATION AND PLAN OF LOWER LEVEL—DEARBORN STREET TO STATE STREET.

is a plan view of the lower level. In the upper right hand corner is shown a typical cross section. This unit with the exception of the street intersection and minor exceptions repeats itself five times between State and Franklin Streets and gives a very fair idea of the appearance of these units. On the upper side of the upper plan there are small stairs which indicate sidewalk lights. In the center elevation are shown the Bedford stone lamps which are in pairs adjacent to each bridge intersection. In the plan view above will be noted the small steps that extend to these Bedford stone lamps with two seats, one opposite each solid portion of balustrade shown in elevation. This also illustrates the method of placing stairs at bridge intersections in order that they will not interfere with the architectural treatment of the arches along the river front. Temporary wooden stairs are placed at Clark Street and Dearborn Street. This is done because the bridges are old and are liable to be torn down at any time. State Street bridge is also an old bridge but when the new one is built, the abutment will undoubtedly be placed further north and thus will not encroach upon the stone stairs.

Ramps at Intersections

The east limits of the South Water Street Improvement except for the removal of the present walls and adjustment of existing pavements will be on the line extending north from the northwest corner of the London Guarantee & Life building. The sidewalks of necessity are very narrow on the south side of the street. A ramp connecting the lower level of Michigan Avenue extends southwest along the river front and reaches the upper level just east of Wabash Avenue, extended to the north. The narrowest throat in this portion of the improvement occurs at its connection to Michigan Avenue. The descending grade from Michigan Avenue to the south was a source of considerable trouble in architectural design. Working in co-operation with the Chicago Plan Commission, this problem was solved by making the balustrade a little lower at the Michigan Avenue connection and running the walk on a slight incline to a point opposite the south portal to the ramp, at which point the balustrade was slightly higher than it is customary to have them. From this point south the balustrade is made solid and is stepped down at each second panel point.

State Street is typical of all approach streets. Franklin Street is built to the finished grade at the present time. The street is level from the north line of Lake Street for a distance of 50 ft. north, from this point it rises at a grade of 2.66% to a point 75 ft. south of the south line of South Water Street. From this point north the grade is 0.75%. This is the maximum grade at which street cars will stand with safety without applying the brakes.

There is a large safety island in the area bounded by East South Water Street, Wabash Avenue, and the River. A circular section at the east end, which for the present will be covered with a concrete sidewalk, is reserved for a future monument, fountain, statuary group or some other type of decoration that may be provided for some time in the future by some civic body, such as the Ferguson Fund. A large Bedford stone vase will be placed on either side of the entrance to the island on the west end. These vases are ornamental and have on their respective faces bronze tablets with appropriate inscriptions. Part of the island is a brick sidewalk composed of Holland-Splits laid on edge with a half-inch white mortar joints. The sidewalk around the outside of the balustrade extending around the entire width of the island is removable in case the traffic should become more congested at some future date and will make considerable more clearance for traffic in this area. At the present time it would be used as a place of refuge for pedestrians. The four large stone lamp posts located at this point have Bedford stone seats at their bases.

Ventilation System

One of the problems we have had to consider in this improvement is the ventilation of the lower level. The covered area is 200,000 square feet or more than 4½ acres. This area will be entirely enclosed on the south except for four street

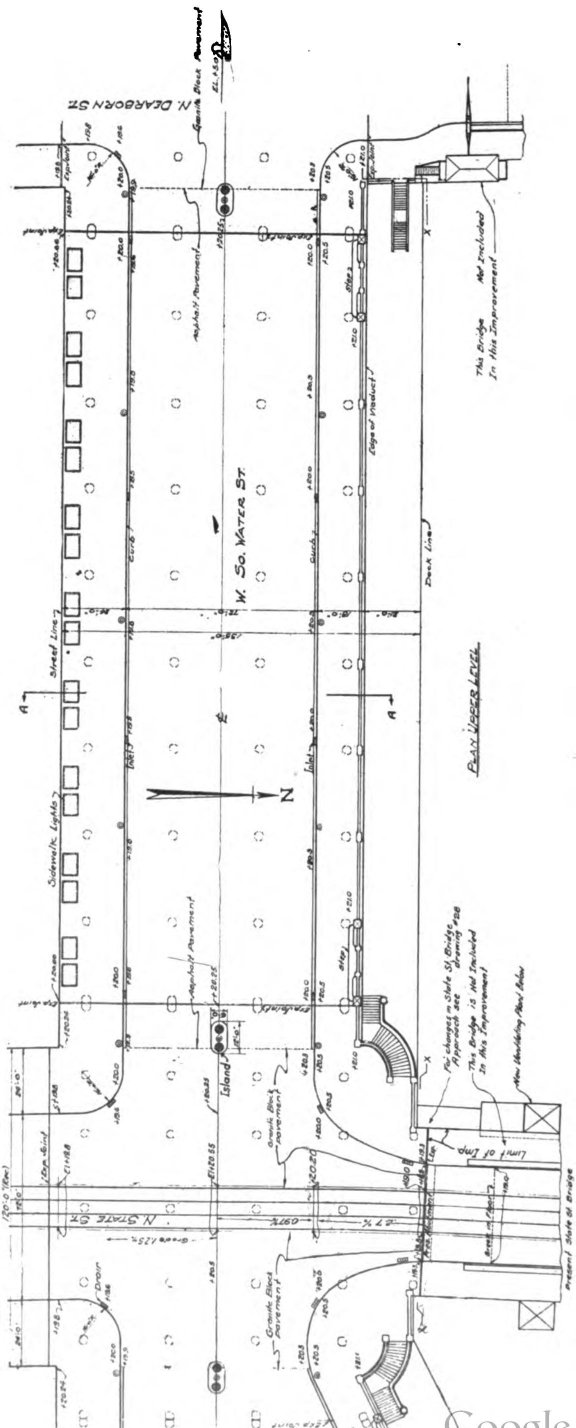


FIG. 4. PLAN OF UPPER LEVEL—DEARBORN TO STATE STREET.

openings. Along the river front it will be partly enclosed by seven bridge abutments, the arches and columns and the ramp wall. We anticipate that the lower level will be used by a great number of automobiles and on account of the gases discharged by them, artificial ventilation will be necessary not only for the comfort but even for the safety of people entering this space.

There are, in fact, three separate ventilating systems, the first extending from the east end to Federal Street, the second from Federal Street to Fork Avenue and the third from Fork Avenue to the end of the two level structure on Market Street. The systems are similar in principle and each consists of ducts along the south side of the street with openings to permit the entrance of air and an exhaust fan at the river front. The fan houses will be at State Street, La Salle Street and Lake Street. Each fan will be driven by a direct connected motor and the capacity of the system will be sufficient to make seven complete changes of air every hour. From the best information we have been able to obtain we believe that will be sufficient to maintain a sufficiently small percentage of carbon monoxide so that danger from that source will be eliminated. The supply of fresh air will, of course, come mainly from the openings along the river front.

Testing and Inspection

The permanence of a concrete structure depends on the method of measuring and mixing the ingredients, on the quality and proportion of the materials and on the methods employed in placing and curing the composite elements of the structure.

Various authorities state that the measuring and mixing of the cement, sand, stone and water can be done quite accurately, provided the Contractor has the desire and is properly equipped to do so and provided also that the inspection is rigid enough. Recent research, however, seems to disprove this. The two elements causing the trouble are the sand and the water. We have very little trouble with the stone because the maximum amount of water therein is not liable to be over 3% and this does not affect the volume of the stone. The cement is dry and to measure accurately the cement, it is only necessary therefore to establish the size of the batches so that one or more full sacks of cement are required for each batch. This disposes of the stone and cement. The difficulty in measuring the sand in such a manner as to maintain a constant proportion between the sand and the other ingredients arises from the fact that the volume of the sand is materially affected by its moisture content. Dry sand will swell as much as 32% when 5% of moisture is added and mixed with sand.

In order to eliminate this uncertainty, it has been proposed to measure the sand in a thoroughly saturated condition, that is inundated and it has been demonstrated that the volume of the sand under these conditions is practically equal to the volume of the sand when thoroughly dry.

In addition to elminating the uncertainties which result from using sand with an unknown moisture content, the use of saturated or inundated sand has the advantage of assisting in or speeding up the hydration of the cement and of producing a mixture that flows more freely with a smaller amount of water and also holds the sand and cement in suspension making a much more consistent mixture. There is a device just placed on the market which measures saturated sand and at the same time measures the water. One of these devices has been ordered and as far as we know this will be the first time it has been used in Chicago.

The quantity of each material to be used will be determined from actual tests of materials purchased for this particular job previous to the pouring of concrete on either the columns or slab. Our specifications are written to cover the so-called water cement ratio, the mix specified being marked as 1:6-1:8-1:5, etc. The water-cement ratio being constant, if the water is increased the cement must likewise be increased.

Tests will be made on the material as it is placed in the forms. The test cylinders will be filled with the mixture from the forms in preference to the

material as it comes from the mixer as the extra time involved and the extra mixing the materials receive in the interval between dumping out of the mixer and placing in the forms will undoubtedly be a factor in increasing the strength of the finished product.

Every precaution will be taken in placing the cement to have all reinforcing steel in its proper place. All chairs and stools will be made of concrete. This is done to prevent having ends of steel chairs or bars exposed on the finished product. We know that small pieces of wire, nails, bolts or bars that reach the surface of concrete sooner or later prevent very unsightly spots. Corrosion will eventually set in and cause rust spots to appear. This structure, being open on the north side and at the water edge, will be subjected to considerable condensation. This then will hasten the corrosion of all exposed metal parts. The finished concrete surface will be rubbed down with carborundum stones where it may be found necessary.

Ground was broken on November 10, 1924, and the construction program calls for the completion of the entire improvement late in 1926. The improvement involves 300,000 cu. yds. of excavation, 120,000 cu. yds. of concrete, 9,200 tons of steel, 135,000 sq. yds. of pavement, and 120,000 lin. ft. of piling. The estimated cost is in the neighborhood of $23,000,000 of which $14,000,000 is for land and $9,000,000 for construction.

DISCUSSION

N. Z. Konstant (A. W. S. E.): Mr. Evans is to be congratulated for the efforts that he made to consider all factors entering the design of a structure of this kind. However, his conception, being familiar with the original calculations, of the temperature effect upon the columns and the consequent increases of their length in proportion to the distance from the center line of the bent is, to my mind, erroneous, for, the temperature stresses in the columns depend upon the angular distortion, the cross sectional area of the deck and the rigidity of the bent as well as the lineal deformation due to expansion or contraction.

The horizontal deflection at the top of any column is not equal to the total change in length, due to a change in temperature, from the center line of the bent to the column, as was here assumed. If it were, the horizontal reactions at the bases of the columns as well as the moments would vanish, a condition which means that the columns have no resistance or are hinged at both ends.

My way of looking at the problem is to consider that the angular and lineal deformation and the accompanying bending moments and reactions at the column bases can be effected by the application of horizontal forces at the top joints. Their magnitudes can be determined from the cross section of the deck and the withstanding column deflections.

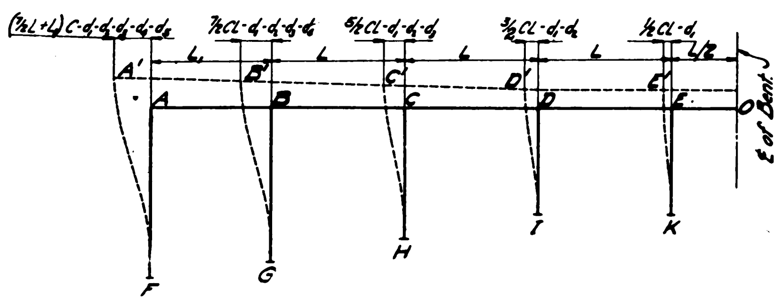
Mr. Evans: Mr. Konstant was working with me for a while, and we discussed it in the office. He is partially correct but not altogether so. The stresses in the end columns are not as severe as in the second columns, but they are more severe in the second columns than any of the rest of the structure.

Mr. Konstant: What I am trying to bring out is that the successive expansion of the structure cannot be taken as the column deflections and the sum of the column end moments, for half of the bent, cannot be equated to zero, as was done. To illustrate the point, let the full lines, Fig. 1, represent the position of half bent before and the dotted lines after distortion, due to a rise in temperature. Denoting the product of the coefficient of expansion by the rise in temperature in detgrees, by C, the deflection of each column, due to its rigidity, is as shown. The terms d_1, d_2, d_3, d_4 and d_5 represent the restrain that the columns EK, DI, CH, BG and AF, respectively, offer against the expansion of the structure and are a measure of

the horizontal reactions at their respective column bases. To find the end moments of all the members the values of all *d's* as well as all the angles of distortion of the joints must be determined. The ten simultaneous lineal equations required can be obtained from the fact that the sum of all moments about a joint is equal to zero and the sum of the send moments of each column divided by the column height must be equal to the horizontal reaction at its base. The horizontal reactions can be expressed in terms of the withstanding deflections *d*, by the definition of the elastic modulus.

According to Mr. Evans' reasoning all *d's* as well as the sum of all the column end moments divided by their respective column lengths, for half bent, are equal to zero. This means that the columns cannot act in bending, contradicting his original conception, that the horizontal reactions are zero and that the cross section of the deck has no bearing on the problem or the columns will be subjected to the same deflections even if a wire is used to connect their upper ends.

Mr. Young: I might say that in the Twelfth Street Viaduct we avoided some of the difficulties the gentleman speaks of by increasing the length of the columns. The sub-piers were cut off probably ten, twelve or fourteen feet below the surface of the ground, and the columns were then extended to that elevation so that they satisfied all the requirements of the slope deflection formulas and kept the stresses within the proper limits. That could not be done on the South Water Street Improvement on account of the fact that it was necessary to provide these subgirders to carry the column loads over the parts of the improvement where there are tunnels and subways.



Makers of Miracles

By Floyd W. Parsons*

Presented December 1, 1924

This is more of a story than an engineering paper, but it touches many things in which engineers have some interest. The speaker's personality is reflected in the succession of facts that he states with the speed of a machine gun. Following is his address in the form that he gave it. The marvels of science that are only mentioned here will probably have considerable effect on the future life of many of us. It is interesting to have a review of them occasionally, just to keep us up-to-date. Editor.

The present age is one of scientific wonders. Right now someone somewhere is working on a method or a device that will change the character of each one's business, his vocation and probably his life. There is not any job that anybody has today that he can say with absolute certainty is a permanent one. The unexpected discovery of a new material may mean the passing of an old industry, and the creation of a new one.

Many people here in this room were born before the invention of the electric light, the dynamo, the telephone and the phonograph. I remember very well myself down in Virginia when I saw the first telephone that came to our town, and I have no doubt that a great many of you here can also remember very well the awe and trepidation with which you first walked up to the phone and talked into it, and how often you watched other people before you ever did it yourself. Most of you here had reached the age of maturity before the coming of the automobile, the X-ray, wireless, motion picture, the aeroplane, the discovery of radium and the development of radio.

If the total age of mankind were to be expressed as 50 years, it is a fact that we could not, measuring in those terms scratch the simplest records on stone until our forty-ninth year. On such a basis printing has only been in use three months, steam four days, electric light day before yesterday, and the automobile and wireless came on our fiftieth birthday. We were taught when we were in school, all of us here present, that the atom was a hard, round, indivisible body beyond which we need never look, and we know today that in the atom alone there is more chemistry than there was a few years ago in the whole field of inorganic chemistry.

People said that the discoveries of the nineteenth century would never be equalled. Let me say that the future is a time of unparalleled mystery and miracles. We no longer applaud the ultra-conservative and the industrial standpatter. The skepticism that confronted Elias Howe and Bell and Watt and Bessemer and Goodyear and Morse and Edison is all gone. It was Sir Humphery Davy who said, "It will be impossible to light London with gas." Tyndall, the great Engilsh physicist, laughed at the idea of electricity. General Benjamin Butler told Edison that he would not give 5c for his invention of the phonograph, and Chauncey Depew refused pointblank to back Bell with his telephone. Goodyear, you remember, was put in jail as being more or less of a crank and a nuisance, and because he could not pay his debts. Stevens, who invented the first locomotive, could not get a bit of attention from the American Congress, and the result was that Stephenson beat him to it in England in patenting the first steam locomotive.

At the present time we are being warned of many things. Some say we are being devoured by our machines. Others say that economic individualism is in its death throes, that at the present time a few people control many, that there are grotesque disparities in the

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rewards of workers. Many of these things are true. You will find that a college professor gets $5000 and the football coach gets $15,000. A splendid engineer will get $7000 or $8000 and a chef in the Waldorf will get $18,000. Crime costs us $10,000,000,000 a year, and there are 1,000,000 people right now that are at dagger's points with law and order. One-fourth of this million people are in jail in some part of the United States at the present time,—all the time. Twelve per cent of our workers are out of employment on an average all the time, in good times and bad. There is no end to our deficiency. I could go on reciting such things for an hour, but no nation, let me say, has ever reached such high moral, physical and intellectual plane before as the United States now occupies.

Our Natural Resources

The principal part is what we will play in the great world industrial drama that is just now opening. Our wealth has increased in less than a century from $30,000,000,000 to $400,000,000,000 and our resources I am not going to talk about —you know what we have in coal and oil and water power and all of the other essential things that go to make a great nation. We have a climate that is a climate for workers, not a climate for poets and dreamers and such. There is no part of the United States so hot that people can't work and no place in our entire land that is so cold that you can't raise crops. Our rainfall is ideal and in every way Nature has blessed us with a climate that should make us able to accomplish the great work that lies before us. Above all else, however, in value are our prospects in the fields of science and engineering. Our research workers are the hope of America. They are the miracle workers and they are the foundation of our security and of our future prosperity.

The American Indians had all the same resources that we now have, but they did nothing with them, because they had not the knowledge, the skill or ability. China, second to our country, has natural resources greater than any other nation on earth, but what are they doing with them? Look at the situation in China today. It takes brains as well as resources to accomplish any great work in the world.

The proofs of our amazing progress are all about us, and yet we hardly ever recognize them in the aggregate. We do know that here something has happened and there something has happened, and it is like a dollar here and a dollar there and ten dollars over there—it doesn't amount to very much. It is the great aggregate of all of these developments that are going on that is going to give us a real idea of what we have to look forward to in our lives.

We now have a metal so hard that it will turn a lathe tool and yet so porous that it will absorb oil like a sponge. It is a copper-tin-bronze, in which graphite is incorporated. It can be used in all kinds of moving parts of motors and other machines, that have been difficult of lubrication in the past. We have discovered a way to fuse ordinary quartz rock. It has less expansion, a higher melting point and greater hardness, and with ever so many splendid electrical properties that make it a splendid substitute for platinum. We can fuse old and new rubber and that will aid greatly in the reduction of tire costs.

Many New Materials

We have a non-tarnishing silver, non-rust steel and an aluminum paint that can be used where one coat will hide all old designs. We have a new liquid fuel that very likely will come near to doubling the mileage of motor cars. We are making artificial silk from spruce wood. We have perfected an ultra-audible microphone. Let us not forget that the human ear can only record vibrations running from 40 to 20,000 per second. With this ultra-audible microphone there is no reason for doubting that we will open up a field of sound that will run up as high as 1,000,000 vibrations per second. To comprehend what that will mean, and this is an age of vibrations, the X-ray and the ultra violet and all the great things that are

happening are really in the field of vibrations, but just to get an idea of what that means, when you think that we can only hear these vibrations from 40 to 20,000, and it is perfectly possible to hear up to 1,000,000 vibrations per second, you can see what an enormous field lies before us, and how many great things may happen in the field of sound.

An improved mild steel was recently invented that makes possible, thinner plates in ships, so that we can transport heavier cargoes with the same engine power. We all know that iron becomes valueless at high temperatures, because of oxidation. We have developed a new calorizing process that extends the use of iron to very much higher temperatures. We have a new alloy of iron and nickel which has already increased the speed of sending cablegrams 400%.

There are great advances in the arts of illumination and communication, and these advances have made necessary for us to find a way to seal base metals to glass. Heretofore the only thing that was possible was to seal platinum and glass, for other metals expand and contract at different rate than does glass, and it was quite a problem, but already they have attacked that, and now it is possible to seal glass with tungsten and copper and several other metals.

Recover Lost Treasure

We have acquired a new knowledge of air pressure that is making possible the recovery of sunken ocean treasurers, —and don't laugh when I talk about that. You haven't any idea, until you get into the thing, of the tremendous treasurers that lie under the ocean, and do you know that the location of practically all of the ships that have sunk in the last hundred years is pretty well known? It has only been a question of developing measures and methods to raise this sunken treasure. For intsance, off the Coast of Africa there are 3700 bars of silver that went down. They know where it is. In one of the Bays off of Ireland there are $10,000,000 in silver and gold. Off of Cornwall the Lizard, a vessel, sank with $50,000,000 in treasure. The Merida, another vessel, sank off the Virginia Capes, and they know where that is. It has $3,000,000 in treasure. The General Grant sank off of our Coast with $10,000,000, and the Arabia with $5,000,000. You can go on and enumerate hundreds of treasure ships that are lying in various parts of the world under the waters of the oceans.

The manufacture of weather indoors was a tremendous help to a great many industries. The textile industries of England were built up on just one thing, because the weather was perfectly proper. No one believed at that time that you could make weather indoors suitable to agree with the process that you were trying to perform, but we are doing it now, and if we will take just one industry, the manufacture of sanitary ware. A short time ago we had to take the green ware and put it on racks for two to eight weeks before it could be baked. Now with this plan of manufacturing weather we are able to have this ready for baking in just a few hours. It has increased the capacity of the sanitary ware factories 125%.

Change in Motor Cars

We have all seen the balloon tires on automobiles. We have not given much real attention to them, just like everything else that is going on, we take it more or less as a matter of course. There is not any question but what it will mean very much lighter cars or cars that will have a very much longer life. I am inclined to think that the manufacturers in choosing between the two things will lower the price of cars and make them lighter, so they will have about the same life that they have today. That is a revolutionary thing for the fellow who owns or intends to buy motor cars. After a little time we will undoubtedly be having motor cars in which the idea will be to run with the throttle open. It is now the fault of the salesmen who have been selling automobiles that we go in for speed, but someone will came along and appeal to that great mass of people who want economy and they will then build an automobile that will only go so fast, be reliable and run on half the gas they

use today. That can be largely done by having it so that it will run with the throttle wide open most of the time.

Take for example the automatic train control signals, a recent invention doing away entirely with the human factor, and safeguarding life. Even if the engineer or the switch tower operator should drop dead there can't be any accident. Five thousand miles of our American railroads have just recently been equipped with these automatic train stops.

Our Federal engineers have perfected a way of analyzing the gases dissolved in underground waters, and this is helping us to locate oil and gas fields with greater certainty, and will save millions of dollars. The hydrocarbons present in the water serve to indicate whether oil or gas sands exist in the strata the water passed through.

Study of Foods

The benefits of research are nowhere more evident than in the production and distribution of foodstuffs. Take your own university down here, the University of Illinois. It showed that potassium would increase corn yield by 28 bushels per acre on all lands where they have peat soils. On an expenditure of $25 for labor and fertilizer they have shown it is possible to increase peach yield 130 bushels per acre, apple trees 27 barrels per acre. By using a clover-lime treatment they are increasing the production of corn from 14 to 31 bushels per acre right here in Illinois. It does not seem much, but I am citing these things to give you the big aggregate picture of development happening all the time, almost every day.

Luther Burbank, the wizard out in California, is doing marvelous things. Not so long ago he got an order for 20,000 prune trees. It is impossible to grow quickly that many prune trues, but he said, "I will take the order." He went and planted almond seeds. They sprout with the same rapidity that corn does. He put 25,000 of these almond seeds in the ground. In a little while they sprouted. He put them in nursery rows and they became sturdy little almond trees. About this time he got a great crowd of workers to get busy in a nearby prune orchard that had just started to grow buds. They went out and got the buds from the prune trees and he grafted a bud on each one of the little almond trees. He broke off the top and the grafting grew on up and exactly on time he was able to deliver his 20,000 prune trees, which were started with almond seeds. Those things are really wonderful. Other typical things that he has been doing are disarming the cactus and growing the Burbank potato.

The chief food staple is the potato. We are increasing the yield of the potato in many places, and soon all over the world, by cutting up new seed potatoes and dipping them into a weak solution of nitrate of soda for 50 minutes before putting them in the ground. In the ordinary way you had to get your seeds from your potatoes and cut them up before you could plant them to make a new growth of potatoes. With these new potatoes so treated they sprout as quickly as the seasoned seed, and they make possible early crops in many parts of the country where they could not have these crops before, and had to send to other locations.

Most of us in the engineering field really have our eyes so glued on our own work that we don't see these things going on, but they do affect our lives. They affect the cost of living, the general prosperity of the country. That is the picture I hope to get to you this evening.

Take the oyster, which is our greatest sea crop. Research is making it entirely a farming operation. It is now reared from artificially fertilized eggs to the setting stage. It is very likely that soon we will have seed oysters reared in a hatchery just as trout are now propagated. That will save us some tens of millions of dollars every year.

Plants exposed to electric light at night grow to twice the size of those that get daylight alone. I have not any doubt at all that electricity will be largely used before very long in increasing the growth of plant life. There is one plant—I have just forgotten its name—I read about it the other day—

at night it closes its leaves. So they took this plant and put it into a dark room and as merely a force of habit, during the day it opened up its leaves—not as much as it used to when the sun was shining, but out of force of habit it did open its leaves and then closed them again at night, although it was away from the sun. So they put electric lights in there. Instead of turning the electric lights on in the day-time they turned them on at night. The plant hesitated for some days and then finally developed a new habit, and every night it opened it leaves when the electric lights were turned on, and in the day time it closed them, indicating the opportunities that lie in that very interesting and wonderful field.

Span of Life Lengthened

Then as to our health, which pertains to our efficiency and in the aggregate means a great deal to the industry of our country. Let us take only one thing. I can only touch just a few high spots. Let us take the endocrine glands. Here alone is a marevelous development going on. I was talking to the Director of Research of the Endocrine Research in New York. He says in these glands are centered most of the efforts toward re-juvenation, and through the use of the gamma ray they expect to get endocrine ionization, and this will retard to a very large extent the coming of old age. I don't doubt at all that within the next twenty-five years that we will reach here in the United States the allotted span of life that is given to us in the Bible of three score and ten years. Fifty years ago the expectancy of life at birth was 35 years. Today it runs about 57 years. I don't doubt with our progress going on as it is that within a quarter of a century we will get it up to 70 years, and I have no doubt, if we were to come back again in 50 or 100 years from now that we would find the thing going considerably beyond 100 years. I don't believe that there is the slightest doubt but what we will rapidly commence to conquer old age and wrinkled faces and all that tired feeling when you get up in the morning. These endocrine glands control all brain functions, and the experiments that are now going on indicate that they will be a definite control of these things with the aid of electricity and gamma rays for insanity. There are marvelous stories in New York. I visited the hospital down there where they are putting on new noses and lips and ears and all these things and doing grafting, what they call plastic surgery. There is a story in that that a man familiar with it and able to tell it to you could hold your attention for an hour, the things they are doing in cancer and all of these different things.

Wonders in Medicine

In cancer the X-ray is accomplishing wonderful work and in the matter of the bacteria, the cancer bacteria—and I speak of cancer because it is one of the few things that is increasing and we have not gotten control of it, but I think we are on our way, just as we were in getting anti-toxins and serums for diphtheria, which is now becoming almost extinct and soon will be entirely eliminated from our lives. I think we are making that progress in cancer. One investigator isolated the cancer bac-teria in plants recently. It is believed by the medical fraternity that that will lead to the discovery of the germ in the human body.

Especially in the field of nutrition are we discovering valuable facts. Let us take fish foods,—salt water fish contains from 50 to 200 times as much iodine as milk or meat, and it is a lack of iodine that causes disorders of the thyroid gland. For instance, in Japan it is an interesting fact that there they eat a great deal of saltwater fish and there is practically no goiter in Japan. These experiments on fish with regard to get-ting the iodine content have come just within the last two years. They are getting the content in oysters and all kinds of salt water fish, and it indicates quite some progress in this matter of determining our necessary food rations with regard to preserving our health.

You all know that cod liver oil is a cure for rickets. But so is sunshine. Cod liver oil contains one of the soluble vitamines. And experiments have also

shown that cod liver oil, strange as it may seem, gives off ultra violet rays.

Uses of Radio

Radio is on the way, if you will only look at it from its long distance viewpoint, to create throughout the world a universal language. Nothing has ever happened since the beginning of time that had the tendency to give us a universal language such as radio has. The transmitters are being installed at fire headquarters and the receiving on fire apparatus in Vienna, and it is working fine. Fire engines start out to a fire in a big city, and they go and they come back leisurely to the firehouse, and they find that long ago they should have been going to a second fire. They did not know it was there. They were not on hand to get the notice and some other engines from other places had to go. With radio, receivers on the wagons and engines they can keep in touch with the firehouse and go right on to any other fire or attend to any other emergency right away without any waste of time. In Berlin a certain group of policemen are equipped with radio sets. They say they are working very satisfactorily. A short time ago on the trains coming from New York they put on radio apparatus, and the people on the 20th Century and the trains out of New York on election night and the next day got all the news and all the returns as well as if they had been in front of the bulletin board in Chicago or New York City. They found the movement of the trains around curves, steel cars, nothing at all had a particle of effect on the apparatus, and on the reception of radio. It is perfectly evident that it is only a matter of months, you might say, when you can talk to your house here in Chicago off the 20th Century when you are on your way to New York. Those things are wonderful. They are sneaking up on us and we don't really realize it until we are there, and then we rather take them more or less as a matter of course.

They are using this radio successfully in cutting down accidents, in saving shipping, as fog signals. The United States has more radio fog signal stations now than any other country in the world. The Geodetic Survey is using them in marine surveying, using the radio and sound waves. They shoot off a bomb and the sound waves are conveyed to the parts of the shore and picked up automatically and transferred back to them by radio.

Saving Waste Products

Everywhere there are great savings through science and research. Seven thousand tons of news print are used daily in the United States. We are coming to a time when we at least will collect one-half of that and de-ink it and save it, and do you know that one-half of the daily consumption of news print in the United States is equivalent to a cut of timber on 300,000 acres of timberland? Think what that saving means to you. Now begin to get the picture of the aggregate of all these things, and then picture the future of America from that aggregate, because every time we save $1,000, $10,000, $1,000,000, we get our little share of it somewhere in prosperity, in the cost of living and in the growth of business.

Non-rot wood is being made from sawdust plus chalk and a few chemicals. You can plane it and saw it, nail it, varnish it, drill it, paint it. They are also making synthetic wood from the waste products of the paper mills, and ever so many other kinds of synthetic wood are made now and used for wallboard, even for the bodies of automobiles. In many places 80% of the gross production of our slate quarries that just a few years ago was discarded is now pulverized and used to give a filler to rubber.

The discovery of Arkady yeast food is saving American bakers $40,000 daily. They can manufacture 12 pounds more bread per barrel of flour and this discovery saves 20% of the sugar content and one-half of the yeast content, and gives us a much better bread.

A few years ago there were huge piles of cottonseed wasted throughout all our Southland. Now the products from it

run into several hundreds of millions of dollars a year. Just think that the cottonseed part of the cotton crop now means two-thirds the value of the total crop. Mattresses are now stuffed with the linters. Eggs are fried in the oil. Soaps, paints, washing compounds are made from this same by-product, cottonseed oil. Other by-products of cottonseed oil are put into combs, artificial silks, writing paper, explosives, artificial leather, and even into salad dressings. The hulls and the meal from the cottonseed are used to fatten our cattle and provide us with steaks for our dinner. Not satisfied with that, they took the oil out of the kettle and subjected it to a hydrogenation process, giving us an odorless and tasteless oil which is placed in the edible class, and now consumes about 50% of this entire production of cottonseed oil.

Not so long ago we got all of our yeast from the breweries and they saw prohibition coming, and the scientists and chemists said, "We have got to work fast or we will have a ruined industry." The succeeded in perfecting a process whereby most the yeast used in the United States is now made from molasses, which saved that industry. It shows what wonderful things chemists can do when they get right down to it.

Weather Forecasting

Coming to some interesting things, such as long distance weather forecasting, I don't know of anything that strikes me as being more romantic than has happened in recent years. I have a great deal of faith in that, because I have watched it for several years in the past. I followed the predictions that were made several years ago that last year we would have drought in California and that we would have wet spells in certain islands and certain sections of the United States. Now, the story of this goes about this way. With these very finely developed meteorological instruments that have now been perfected and that were started about 1905 or 1906, they have been able to measure the heat of the sun that is given to the atmosphere of the earth per year, and they have established from that a solar constant which is estimated to be, in round figures, 1.94, which means the amount of heat per unit of the atmosphere per year.

Now, in 1917, the solar constant went up from 1.94 to 2.00. The result of that extra amount of heat that we got meant that not only the atmosphere of the earth was warmed up, which is not the important part, but that the waters of the earth warmed up, and that the Gulf Stream and the Japan current and these other bodies of warm water were greatly raised in temperature. The raise in temperature of the Gulf Stream in 1919, 1920 and 1921, was about 10 degrees. It widened out perceptibly, and it pushed to a point farther north than was ever known in the history of the country. The oceans north of the Scandanavian countries were ice free along in 1920 and 1921. Now, the effect of the rise in the solar constant in 1917 has its real effect on the earth about two years later, because it takes that long to warm up the oceans and push the cold areas of water back north, widen out the warm streams and change the winds and the general temperatures of the earth. That is what happened, and we had, as a result of this rise in the solar constant, started in 1917, ending 1920, warm winters in 1919, 1920 and 1921, 1922, and a large part of 1923.

Now, early in 1921, the solar constant started to drop, and it has dropped to 1.90 and since then it has not been above that but just three months in the summer of 1923 and it is still down. The result of that drop means colder warm currents in the ocean, generally colder oceans throughout the whole world. It means that the areas of cold water from the Arctics are moving south, as has been proved by more than 1000 log readings of vessels throughout the whole world, now being kept. Last winter in Russia was one of the coldest winters in about ten years, and that effect is beginning to push south. We look for a colder winter this year, but the full effect is expected to be felt in 1925-26.

Now, an interesting thing in connection with this is that, for instance, in 1816, we had a year, I might say, with-

out a summer. We had a black frost in every month of the summer. We had a half inch of ice on the fourth of July. We did not raise any crops of importance north of the Mason and Dixon line in the United States. We had a calamitous year. Now, the outlook is for a bad winter. It might be something on the order of 1816, so far as our records go. There are some indications that it will be very cold. Anyway, it is a tremendously interesting scientific development that does not come from a lot of people who go by ground hog predictions. They are meteorologists who are not saying anything at all, probably would much rather not say anything, but they are not the kind that talk. We fellows that write get onto these things and write and talk about them, and they would probably much rather that we wouldn't. That is a tremendously interesting development that will affect industry and business.

It is a fine thing for people that are in lines that manufacture textiles and other things or heating products or what-not, that have anything to do with warm or cold weather. It is a good thing to know in advance about these things, and it is even a good thing to prepare in advance. We probably won't prepare for these things until we find for sure they are perfectly true. This matter has been taken before the Board of Directors of one gas company and they are taking action in accordance with these forecasts and predictions. It is a wise thing to do and cost them nothing if it doesn't come true. I might say that we get a maximum of heat when we have a minimum of sun spots, and we get a minimum of heat when we have a maximum of sun spots. Sun spots are thought to be dust clouds that shut off the sun's heat and radiation.

New Uses for Old Materials

All around us we are finding new uses for old materials. Take rubber latex. They have found a way to make cements to fasten metal to glass, paper to metal and mica to mica, also they impregnate stuffings for pillows with it and then vulcanize it. Take an ordinary pillow. You sit on it and after about a year there is no give to it at all. It is mashed down and you want to throw it away. You take that stuffing and immerse it in a bath of rubber latex and it can be vulcanized and it is there forever. It never loses its elasticity. You can take it out of the pillow or mattress and wash it and put it back in again. It is a wonderful thing. These are small things, but in the aggregate they amount to a great deal. In other words, I have gone over the list, and we found that there were 30,000 uses for rubber latex, different uses, where a short time ago no one thought of anything but making raincoats and automobile tires.

In Germany they are using potatoes, making them a substitute for 30% of the malt in beer. The older the potatoes, the more nearly rotten they are, the better they work. They use them in shoe polish and they make a splendid shoe polish. In Russia they are planting a large acreage to sunflowers, and they are taking the stalks and getting 175 pounds of potash per acre from it. One of the biggest companies in America, if not the biggest, that handles corn products, has gone into making sugar from corn, and would you believe me, they are making one-half million pounds of sugar from corn every day right now? Think what that means to the sugar cane industry. No matter what business you are in, you can't tell what next year is going to bring, and the fellow that sits tight and doesn't pay any attention to these things may find that he has a competitor that has put him out of business, and he is out looking for a job.

One worker in a plant felt the siren call for corn liquor and he was unable to get any, so he took a swallow of butyl alcohol. He passed out cold for 24 hours, and just about the time they gave him up and were getting ready to think about burying him, he came to. The chemist thought that was funny—it had never happened before—what is going on? They got busy and investigated the butyl alcohol, and now they have succeeded in getting butane from it, and they find that this serves as a very satisfactory substitute for cocaine.

It is a good thing to question every-

thing that we throw away, no matter what business you are in. Go to your office or your plant tomorrow and say, "What are we throwing away? Can't we do something with it?" If every man in America started that inquiry and kept it up day after day for some weeks in his own office and plant, the first thing you know we'd be saving some tens of millions of dollars now wasted.

There are 20,000,000 tons of corn cobs in the United States that were wasted a short time ago. They are making all kinds of pipes out of them, and a lot of other things, but above all, they are getting furfural. A short time ago we only got or used 100 pounds of furfural in the United States every year, and it cost $30 a pound. Now the furfural resins are used in electrical equipment, radio equipment, phonograph records, fungicides, germicides, varnish remover, etc., and they are getting 5 tons from 50 tons of cobs, and getting it for 25 cents a pound.

Eliminate Wastes

The waste from non-standardization that the government has talked to you so much about is costing us $7,000,000,000 a year. We make 6118 different styles of axes, 552 different styles of fencing, 714 sink traps, 8000 varities of piston rings for motors, 289 different styles of the American flag. They have got busy on a lot of these industries and have cut down 86%. In other words, they have effected an 86% elimination of varieties in all of the industries that they have investigated, and have formed a cooperative alliance with, the indutries that have agreed to cut down, and all will have to come to it.

We are even cutting out our waste from crime. I said earlier in this article that crime costs us about $10,000,000,000, taking crime of all kinds, the necessity of maintaining our police forces, our jails, feeding the people that are in them, all those things. Science is helping us here, as it is every place else, so we again get another item to add to the aggregate. We can telephone the photos of criminals or anyone else. We even recently discovered a way to telephone their finger prints. A scrap of bone to the scientist now will very likely tell the age, sex, height of a victim, and an entire hand will come very near telling his whole life's history. One expert gives his attention to dust entirely. There was a crime committed and they arrested three men as being the perpetrators. They did not get much out of them. They turned it over to the dust expert and he made them take off their clothes. He put each one's clothes in a separate bag and then he shook it. Then he took the dust out and analyzed it. The first bag, he said the fellow was a mason the second, a carpenter, the third a coal dealer, and the crime was solved.

After the battle of Waterloo the British realized that it was so absolutely necessary to have ships that they started a campaign and they all went out and planted acorns, acorns to grow oaks to build ships. That is just about the foresight that some of us have even today. We can't conceive of anything being used for anything except what it is used for today. Acorns to build ships, when there was not an acorn that grew into a tree that could have gone into a ship, because they were built of steel by the time the trees grew up.

Problems Can Be Solved

The problems that are now before us are many. Not one of them is insolvable, at least we should say none are insolvable. It took several thousand years to learn to count up to 20. I was reading a little book on astronomy the other day, one of the most interesting things I ever read. The tribes in the South Sea Island somehow or other never could count above 5. Their whole history showed they never got beyond 5 —they only used one hand was the reason. Over in Egypt they suddenly got the idea of using both hands and they counted to 10. That was some hundreds of years later. Then another 1000 years or so later, down in Mexico, the progressive Indians down there, who had a civilization of their own, had figured out a way of counting to 20—they probably used both hands and both feet. That was in the days of the sun and moon—Sunday for the day or the sun and Monday, the day of the moon. The whole story pointed out to me how many

hundreds and thousands of years it took for people to even learn to count. Now think of the progress that we get. Nothing happens in any part of the world, anything of importance in any hidden corner of the earth that we don't hear about it in the evening, if it happened that morning.

In a short time there will be no seasonal ups and downs in the building trades. Our building each year involves an expenditure of about $5,000,000,000, and it has been found that this seasonal up and down is due to custom, and that the climate is not responsible for it. It will mean a great deal to us if we can only get that thought home and can overcome this little seasonal problem in the building trades. It is a simple but tremendously important thing. Just now they are starting in to make a business that has no particular season, and it will actually be done, and then instead of that $5,000,000,000 business being such a high cost of business, due to its seasonal nature, we will save some tens of millions of dollars.

Aerial Navigation

We are coming to a time when we will have aeroplanes without pilots, planes guided by radio, many of them perhaps going to Europe, and then being sent back again. We will have huge dirigibles made of strange alloys, very much larger than anything we have seen. Such a dirigible as the ZR3 seems a monster. It will be a pygmy compared to the future dirigible. It will look to us some few years hence about like the engine in the Grand Central Station in New York does compared to the present day locomotive. Everywhere throughout the land will be mooring masts and landing fields and beacons and searchlights for the ships to land, and the ships will travel the route the crow flies.

Wherever we go there will be no grime and no dirt and if it is across the ocean there will be no sea-sickness. I don't doubt at all that there will be planes that will go across the ocean in some years hence, and it will come very fast when it gets under way, that perhaps will make the journey possibly in three or four hours from New York to London. They will be up 10 miles or maybe more in the air. There are problems up there, because you have got a rare air, problems with the engine, problems with the propellor, none of them but what the airplane engineers say can be solved. The pilots and the people naturally will have oxygen and plenty of artificial heat, but at those high altitudes, so rare and so high, with the winds as they are, it will be perfectly possible, they say, to attain a speed of 800 or 900—I am not giving you what they claim. You think I am exaggerating. You ought to hear the other fellow. I am cutting some hundreds of miles off what they say. They say two hours. I say three hours. That is dream stuff. It is imagination, but Henry Doherty told me just a few years ago, when he talked about putting in a 20,000-volt electric line, they thought he was crazy. I remember old Mr. Leslie, over in Philadelphia, the father of the cement industry, told me about when they first tried to start a Portland cement industry in competition with natural cement, and what people said, the difficulties they met. You know that that has been the history of everything all down through the ages. As I said, today people are not so skeptical. Things are coming so rapidly that the average man today who wants to be a stand-patter, even if he is at heart, is afraid to say so. A few years ago it was the fellow that had the dream, that had the imagination, that had to hide. Today that man doesn't have to hide any more.

Skepticism Gone

Only a few years ago, when I was doing stories in Saturday Evening Post, and all of the crazy inventors from all over the country were hunting me up to try to get attention for something, I used to feel it was a crime. Men that had real splendid ideas came there almost as if they were beaten and hounded, and everything, because people had tabooed them and had placarded them and posted them as being nothing but dreamers and they were almost afraid to talk about some of their

dreams, about getting heat from holes drilled in the earth. Just four or five years ago that was. Now Mr. Rice, of the General Electric Company, and men like that read a paper on it before a great technical society in London. We are liable to find, when we get down 10 miles in the earth, that we will get probably 1000° temperature. That is five years ago, when those men did not dare talk about those things. Now one of the greatest electrical men in the country reads a paper on it before a big technical society. That is how fast things are moving in the United States today.

When I came from New York to Chicago this morning on the train I could not help but feel that this is an old-fashioned way. I was on the Twentieth Century. I seemed to be comfortable. They had Brussels carpet leading up to all four or five of the sections, but I could not help but hark back twenty years, when it got out here in 18 hours. I could not help but feel that it was not so very long ago when the train running from New York to Buffalo, the Empire Express, made it in one hour less than it did today; twenty years ago, when I was a boy down in Virginia, I used to leave there, rather, I used to leave New York at 6:30 in the evening and I got home at 9 a. m. Today, if I go to Virginia, I leave at 6:30 and get there at 9 a. m. In 30 years, there is not much progress, and there is not much chance for progress. I tell you the travel is going to be through the air. It will be safer. It will be just as safe through the inclement weather and storm as it is on any railroad train. Some of them will get busy, I imagine, making $150 airplanes, and it will increase the humor about it a good deal.

We will have aerial taxi service and aerial pullmans. The aerial pullman will go out of the railroad station, and will be pulled to the aerodrome, there it will be pushed off of its wheels onto a chassis of an airplane and away it will go, with all the people in it, without their having to change at all.

All those things sound fantastic, but not a technical man can point to any reason at all why they are not perfectly feasible. If you do you will find you will be very sadly mistaken in a very short time. Science undoubtedly in some sections has robbed earthquakes of their terrors. I don't see any reason at all why the proposals to have combination bearings, springs and shock absorbers in a lot of the buildings would not be perfectly feasible. It might not be used, but the cost would not be much to put them in, and when an earthquake did come, the architect tells us that it would be an absolute insurance, would save the builder the cost of so equipping his house in insurance alone.

Change City Plans

The coming city will be a modern Venice with flowing tides of motors instead of water. There will be three levels in cities like New York, a low level for rail traffic, subways and such. The next level will be for wheeled vehicles, automobiles and the upper level will be for pedestrians, and all of our buildings will be in pyramidal forms, with terraced walls, letting the sunlight come down. Under all of these buildings, where the motors run there will be arcades and you will walk all day in New York or some place like that and never once get into the rain or sunshine, because you will be walking under those covered walks. That is bound to come, and the benefits of it are greatly in favor of the real estate man. In such a case, instead of having a second floor that is not very valuable he'd have a main floor for the motor traffic that will be very valuable, and on the floor above he'd have another main floor for the pedestrians that will be very valuable.

There are compensations which will justify such changes when we are forced to it. Those things never come until you force people to it, but we said a short time ago you could not stop folks from riding automobiles wherever they wanted. Last year I drove to New York every day from the country and parked wherever I pleased. I have not driven the car in two or three months. I can't park it. I get a ticket if I do. The automobile companies will have to sell you an accessory in the

form of a bicycle, and you can park in the country and ride in on a bicycle.

Savings in Fuel

In a short time there won't be any ground oil. But there will be a great shale oil industry in this country. They have all been talking about the enormous production of ground oil. That production reached a peak, and I don't think in the whole history of America that you will ever again see as much oil produced as you saw this year and last year. I don't believe it will ever come up again. I think you have seen the peak and I think you will see a declining production of ground oil from now on until the end of the oil is completed. Geologists tell us there is only enough oil to last us for ten years. In about five years, at the present rate, we will be consuming 10,000,000,000 gallons of gasoline, which is more gasoline than there was oil produced when the world war started. Last year's oil production amounted to 1/10 of all the oil produced in the United States since oil was discovered, and 1/16 of all the oil produced in the world since the beginning of time. Do you know we drilled in this country 25,000 wells in 12 months at a cost of one half billion dollars. That is why you got your enormous production of oil, because our laws are such that it goes by capture, the first man that gets it wins. That is not going to stop, and in ten years we will have practically no oil to carry on our industries at all, which means the coming of other great industries, such as the oil shale industry. It means the complete elimination of the burning of solid coal. It will all have to be processed. Every bit of coal will have to be processed, and that distillation of coal will be as common then and in as large a quantity in a few years from now as the non-distillation of coal is today.

I am not going to talk about my hobby, which is gas, or about smoke or anything, but I will say that when I come to Chicago—New York is not any prince of a place, but my gracious, it is clean compared wtih Chicago, and when I come into this town, and I see the smoke that I saw this morning, that I always see, and these engines running right straight in to the heart of the city, all of the factories around here belching their black smoke out, I can't help but say, my goodness, are these people alive? Why is it they permit this thing to go on? The reason is, I suppose, that you can't discriminate. You can't enforce your smoke laws in a city and say to a factory along a railroad track, that they can't make any smoke here, and then turn around and let a locomotive run up beside the factory into the heart of the town.

Do you know a few years ago in New York the engines ran down Park Avenue. That street was a blot on the city, all little bits of dirty buildings. Their real estate was worth almost nothing, and then what did they do? They electrified the Grand Central Terminal, and those lines out of New York, and today go to New York and see it. The increase in the value of real estate on Park Avenue would pay for the electrification of all the railroads within a hundred miles of New York. I should say that real estate, from what I learned, real estate there has increased from 500 to 1000% in value, and today that dirty little Park Avenue, which no one thought of living on, is the chief residential street of the city. It is a more fashionable street today than Fifth Avenue is. That is what electrification and the elimination of smoke does. It would increase the value of real estate along your railroad tracks here 1000%; if somebody could take that as a contract and go out and electrify the railroad lines into Chicago, and get an option on all the property along there, he could pay for the electrification and make some millions of dollars on the increase of the property alone, and then with that smoke eliminated, then you could begin to enforce your smoke ordinances elsewhere.

I read in the New York Tribune, I think it was, about Chicago was going to be the greatest city in the world, but it will never be the greatest city in the world until it gets clean. It is a dirty city, and I can't make imagine it the greatest city in the world, if it is dirty. You can't have the right kind of architecture. I think you people that are the engineers are the fellows that ought to do that.

Some Rights and Duties of Witnesses

By JOHN W. ALVORD, C. E., Past Pres. W. S. E.

Contributed

WHILE everyone is liable at some time in his experience to be called to the witness stand, engineers, doctors and other professional men are especially subject to this sort of duty. Therefore, it should ultimately be a part of their training, ably and clearly to present evidence and fully understand the rules properly provided for such procedure.

Witnesses are the subject of much undeserved ridicule, and doubtless to the legal mind, they often act strangely and unnaturally, but it is to be remembered that they are often forced into a responsibility to which they are entirely unaccustomed, and are there confronted with conditions which they do not understand and which often prove embarrassing to them. The wonder is that they do as well as they do, under the circumstances. A knowledge of the rights as well as the duties of witnesses is, therefore, quite desirable for the well intentioned man who desires to present evidence properly. We hear much of the skill of examiners and their triumphs over recalcitrant witnesses, but all this takes place under circumstances where obviously they hold distinct advantages. On the other hand we hear little of good witness work or reasonable consideration for the rights of witnesses.

First of all it should be remembered that when one is testifying on the witness stand he is in reality informing the Judge (or the Jury, if there is one). He is not talking for the benefit of the spectators or not even for the questioner. It is necessary, of course, to follow the questioner closely and keep his traits and personality in mind, but it must always be borne in mind that the questioner is only making up a record for the Judge and in reality it is the Judge to whom the witness is addressing his evidence. Therefore, the personality of the Judge should always be kept in mind as far as possible, in framing answers to the questioner. In the rapid fire of an exciting cross-examination, this is not always possible, but one will do well to remember as often as possible that the Judge is devoting a considerable part of his time to a study of the personality and viewpoint of the witness as well as the subject matter of the evidence he is presenting.

State Personal Qualifications

In giving specialized testimony on intricate or technical subjects, it is necessary that the experience of the witness with such matters be placed on the record in order that the Judge may know what weight to give to his opinion. There are many pitfalls here, both for the Court and for the Witness. It is not infrequently the case that a witness of unusually wide experience and good judgment unfortunately will prejudice the court against him in advance, by the very natural pride he takes in his past record, and thus perhaps lessen the weight of his opinion with the court.

On the other hand a novice, by skillfully relating his record in a modest manner, frequently obtains for his opinion more weight than his real experience would justify. It is a crude mistake to show too much egotism in reviewing one's business or professional life story, but is equally a mistake to effect a false modesty about the matter.

The record of the witness' experience is a necessity for the enlightenment of the court and while it is unfortunate that it must be related personally, it seems to be a necessity; consequently witnesses should give this part of their work the closest attention in order that they may avoid painful errors in good taste which may prejudice their case. This is another example where it is well to remember that the witness is talking to the Judge and not to the spectators.

It is important to remember next that in court work witnesses are being weighed in the balance as well as the question at issue. The testimony of a

witness is often effective or ineffective with the Court by reason of its impartiality and sincerity, or the reverse, and the nearer one can approach to impersonal ideals, the more weight the Court will ordinarily attach to the subject matter presented.

Manner Must Be Sincere

A witness is always under close observation from two standpoints, first the subject matter presented and second the manner of its presentation. The latter is almost as fully weighed as the former though often more unconsciously. When we say a witness is honest, we often mean more particularly, that he is sincere and impartial as well as truthful and we reach this conclusion in subtle and complex ways from personality, manner, tone or gesture, which are often the most definite part of what is said. No preparation involving substituted artificiality, can successfully bring about an appearance of impartiality and sincerity. The best way to acquire such an attitude is by thorough and careful preparation in the assimilation of all the facts in the case and an impersonal manner of presenting them. It is well to decide fully beforehand, in all fairness, what opposing contentions must be admitted as well as what must be opposed. A conviction that the main facts that one is presenting are fully true, that they have been carefully checked and are obviously uncontrovertable, subconsciously developes a convincing atmosphere of sincerity and impartiality which is all the stronger because it comes about in an entirely natural manner. Besides this, when one knows that his case is well fortified by facts he can afford to make happy admissions to opposing viewpoints, that actually strengthen rather than weaken his main contention.

What Constitutes Truth

A witness is always sworn to tell the truth, but as truth is often very relative matter this is not so simple as it sounds. The fact is that even Philosophy is not yet able to say fully what truth really is. Apparently the best that it can say is that "The truth of any propostiion consists in some relation to reality." "Reality" is defined as "that mode of being, by virtue of which the real thing, is as it is, irrespective of what any mind, or any definite collection of minds may represent it to be." It is evident then, that truth, in most instances is not necessarily the same for different minds. Truth is indeed the approach to finality which repeated experience has found to be unalterable or nearly so, but in practical life we accept as true many things which can hardly meet this severe test. A more practicable definition, therefore, is that "Truth is the conformity of things to their essential principles." Thus certain truths in mathematics or physics appear to be very near to absloute reality, largely because their phenomena can be repeated at will, independent of time, and so repeatedly verified by experience. But other truths, more involved in time, such as events in history, which can never be exactly repeated at will, are much more relative truth, because their relation to absolute reality cannot be determined.

It follows, therefore, that in ordinary life, all our statements are, in the main, only rough approximations to what we mean to convey, and it should not be disconcerting to us to find that what is truth to one mind is not truth to another. Men always approach truth from different viewpoints and see it with different interests, hence the necessity for reconciliation through Courts, arbitration, exchange of viewpoint and language of precision. The human mind perceives the world about it only through our sense impressions which are admittedly imperfect translators of the outer reality and to compensate for this our experience has to be drawn upon for interpretation and verification. Thus it is that experience is often more largely the arbitrator of what is truth than is immediate sense impression.

Positive Statements

As a practical result of all this, it is therefore desirable that a witness be positive in asserting truth that he has

repeatedly verified by experience and qualify only statements in which such repeated verification has not taken place. Thus he should be careful not to assert matters which have no verification in personal observation or experience, leaving to the Court the task of comparing and sifting out the ultimate adjustment of his views. This psychological and metaphysical principle is pretty well understood by the legally trained mind and forms the basis of the rules by which evidence is admitted to the record of the courts.

Cross examination is the most effective weapon the law has against incorrect, mistaken or positively dishonest testimony. The greatest embarrassment a witness can face results from an unwise attempt to uphold an equivocal position with entire positiveness. If a client insists on putting a conscientious witness on the stand under such circumstances, he must not be surprised at prompt and ready admissions to opposing facts when they are demanded. No other honorable course is open, if the admission needs further explanation or modification, it is for the client's own attorney to bring it out on rebuttal. Many otherwise capable and conscientious witnesses greatly mar their testimony by trying to introduce too many modifying circumstances into their admissions of those kinds of facts which are not wholly favorable to their client's contention. Thus they not only create an unfavorable impression, but also improperly forstall the duties of their client's attorney.

Practices of Examiners

Long continued success in exposing dishonest witnesses or ferreting out mistaken or incorrect testimony leads many lawyers, and some very intelligent ones as well, to apply certain rather discourteous practices, justifiable perhaps in cases of rank dishonesty, but hardly respectable enough to apply to all classes of witnesses, creditable as well as discreditable. Such "tricks," for they sometimes cannot properly be called by any other name, are almost always out of place in cases in which engineers or other professional men of good standing are concerned though of course, even here, there are sometimes surprising exceptions to the general rule, for no profession has a monopoly of the high minded. It is to some of the more important of these regrettable practices that we wish to call attention.

First, the cross examiner often attempts to hurry or frighten the witness into partial admissions that are not fully thought out, and in other ingenious ways to prevent him from fully recalling his facts before answering. The net effect of this is to mislead him, if possible, into admissions which, to him, are not true. This result is accomplished in different ways, sometimes by an attitude of anger, impatience, or disgust at the apparent want of intelligence or honesty of the witness. Sometimes the necessary distraction is caused by walking around restlessly in front of the witness, shaking or holding a pointed finger at him, or even assuming a threatening attitude as though bodily injury would follow a misstatement.

To meet such an attack respectfully, one must at all hazards keep cool, take plenty of time, concentrate on the question asked, and above all, avoid any exhibition of anger or even irritation. All this is much easier to do when one realizes that all this by-play is simply the cross-examiners "game" and really means nothing more. The difficult thing, under such circumstances is to keep one's attention centered on the question. When the question is not perfectly remembered, it can be regained by asking the reporter to read it. It is safe to do this in any event, as it is a quiet notice to the examiner that one does not intend to be unduly hurried. The witness should know that he always has the right to have the question fully and clearly in his mind at whatever cost of time and patience to others in the case, but having done this he should, without being captious or discourteous, be careful to make his answer simple, clear, responsive and not argumentative.

Second, a very common trick of many cross-examiners is to mis-state a prior answer, purposely twisting it out of its

original meaning into a different meaning not intended by the witness, and then, before this is fully realized, building upon it a new question which distracts attention from the misstatement. A little experience soon teaches a witness to be on his guard, whenever the examiner begins to quote his prior answers, and if they do not sound "right" to him he may properly cast doubt upon the examiners memory or call for the record if possible. Usually it is difficult to locate a prior answer unless it is in the previous days record which has been written up, in which case it can be read, but if not found, it is proper for the witness to repeat the answer as he remembers having stated it originally. All this is naturally disconcerting to a cross-examiner who is employing "hurry" as a weapon of attack.

Show Respect and Courtesy

It is always a wise rule to show respect and courtesy to the examiner whether one really feels it or not. The witness should not put himself on the examiner's level by making any useless retorts or showing him contempt in any way. He should remember that in reality he is talking to the Judge, and the Judge will regret to see him encumber the record with irrevelant personalities. His testimony will rank much higher with the Judge if he shows that he can be patient under the most unwarranted provocation.

Third, a cross examiner who does not want the truth stated as the witness sees it, will frequently resort to interruptions to his answer, which do not allow the witness to complete fully what he wished to say. This is sometimes a difficult situation to meet because if done skillfully it appears to be unintentional and therefore pardonable. Many times it is probably unintentional, but as soon as it is observed to be an intentional and habitual procedure and a serious interference, it may be properly checked by a request by the witness for permission to complete his unfinished answer. This should only be done on some occasion when the answer is an important one. It is also wise to have the reporter read the former question to be sure that the answer is clear and responsive.

Of course all this is quite as disconcerting to the cross-examiner as the original interruption was to the witness, and it is a rebuke which should not be resorted to for the sake of a rebuke, but really to further clear presentation and proper precedure. One such request in a case will usually be found to be sufficient for most cross-examiners unless they are constitutionally impatient and cannot readily overcome this discourteous habit.

Of course the old trick of demanding "yes" or "no" to a question is now pretty well ventilated and exploded. One may well answer many questions by "yes" or "no" whenever he properly can, but when the cross-examiner demands such an answer it is well to be cautious. "Yes" or "no" wholly affirms or denies a proposition, and if the proposition is complex it should be separated into parts or else answered with qualifications. Of the same character is the habit some attorneys have of asking double or triple questions in one, or long and involved questions, such as should be carefully dissected for separate answers. Sometimes this can be done readily by the witness, but if he finds any embarrassment in doing so, it is entirely proper for him to ask the cross-examiner to separate such complex questions into simple ones.

Give Direct Answers

It is the duty of the witness to give clear, direct, and responsive answers wherever he can. Many witnesses are constitutionally unable to do this, and Attorneys have their troubles with rambling minds unable to concentrate for any length of time on the subject in hand. That is the other side of the story, but obviously does not justify the harassing of competent minded men who are fairly alert, honest and mentally capable.

It is safe to say that most examiners take delight in making the witness angry if it can be done, successfully, for usually this will seriously reduce

his efficiency, may provoke unintentional admissions, and often renders the witness incapable of connected thought for some time. In some cases it may provoke foolish display of resentment. Sometimes such resentment can be excited by sly insinuations and at other times by open insult such as suggesting that the witness is testifying for pay, or is influenced by the size of his fee, or is otherwise controlled by mean or unworthy motives.

It is needless to say that a witness is hopelessly lost if he gives way to temper on the witness stand. It must be considered as a part of the "game" to take insult with equanimity. Nor will the Judge often interfere, first because the witness' motives are a proper subject for investigation; second, because there are times when such procedure gives valuable results in dishonest witnesses; third, because the Court is naturally sympathetic with his profession and its dignity, and sometimes at least, because he may be quite willing to rebuke a witness whom he may never see again for conduct he would frequently pass over in a legal acquaintance constantly practicing before him.

Time to Answer

While a witness is entitled to be given time to answer properly the questions propounded to him, he should not unduly trespass on the privilege, for time in the courts is always valuable. Nor should a witness assume a halting or timid manner if he can possibly avoid it, especially if he thoroughly understands his case as he should. Nothing tempts a cross-examiner into a prolonged examination more than a timid or halting witness, especially one who has every appearance of concealing something. A witness who clearly knows what he knows, and equally well knows what he does not know, often presents a formidable task for cross-examination and is frequently dropped after a few questions.

It is by no means intended to be inferred from what is said here, that with many witnesses of low morality where deceit, equivocation, or actual prejury is obvious, all the ingenuity and resource of the examiner is not at times justifiable. What is to be deplored is the poor discrimination that applies such questionable methods to conscientious, inexperienced or diffident witnesses who obviously deserve more courtesy. No one is better fitted to discover such distinctions than the legally trained mind thoroughly familiar as it usually becomes with all kinds of human nature. It is a situation not without its justifiable humor when an examiner, accustomed indiscriminately to apply questionable methods to the inexperienced and the unworthy alike, is unexpectedly confronted with a witness who is his intellectual equal, at least, and who not only thoroughly knows his duties but his rights as well.

The cleverest kind of a cross-examination which one can encounter is that which, while conducted with the utmost politeness and consideration personally, nevertheless builds up an apparently simple situation by direct and easy questions which ultimately confound the witness by confronting one of his opinions with another widely different one, both drawn from the same conditions.

This is real skill, but is accomplished only by careful preparation in advance, not only of the facts, but also of the idiosyncracies of the witness. Beware then, of the prematurely exultant feeling which steals over one sometimes as a witness, that he is finding the examiner to be an amiable and pleasant gentleman who is asking very easy questions, probably only for his information. This sensation too often results in a climax which may take one long for the rougher and more obvious type of blustering examiner.

Finally, it should be repeated, that thorough preparation is the secret of good testimony. The more a witness' memory is thoroughly and fairly "stuffed" with the essential facts of his cause, the more truth will abundantly overflow from him when he is cross-examined and the more he will be respected and handled with caution. For in testimony as in impromptu after-dinner addresses, nothing should be left to chance if it can be avoided.

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The Sewage Disposal Problem of Chicago

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Diversion of water from Lake Michigan by the Sanitary District of Chicago is responsible for only sixteen percent of the lowering of lake levels that has recently caused such a storm of protest. This can be restored by regulating works which Chicago offers to build and maintain. Mr. Fuller herein describes the situation in all its elements and makes the pertinent suggestion that the President of the United States call all interested parties together for a conference.—Editor.

CHICAGO'S sewage disposal problem has been of unusual interest since the early days of this rapidly growing metropolitan district. Never has it attracted more attention than now, owing to the recent decision of the U. S. Supreme Court that the District is not to divert more Lake Michigan water than permitted by the War Department, and also because various interests are unifying their efforts to stop Chicago from its alleged stealing of lake water and interfering with lake transportation and power development. During these stirring events the Sanitary District has proceeded with the carrying out of its program, authorized in 1921 by the Legislature of Illinois, to build treatment plants. At the same time it is seeking to arrive at the most advantageous use it can make of the Main Drainage Canal and its branches. In this effort it recently sought the advice of a Board of Engineers, 28 in number, to review the District program and make such recommendations as it saw fit. Some of the findings of this Board of Review I shall touch upon. •

There is probably no more complex engineering problem in the United States today than that of determining the best utilization of the Chicago Drainage Canal. It can only be understood in all its ramifications by going back to the conditions at the time it was designed and by studying the development of the Canal itself, with its antecedents, of lake transportation and of power utilization at Niagara since the Canal was built.

Diversion of Chicago Sewage Into the I. & M. Canal

In the early eighties, the growth of Chicago and its suburbs was very rapid. The sewage of the city was discharged into the Chicago River and a part of it, diluted with river water, was discharged at Bridgeport into the Illinois and Michigan Canal, which had been enlarged at the expense of the City of Chicago about fifteen years earlier. After storms, a large part of the sewage and street filth was carried into the River and thence into Lake Michigan.

The only source of water supply for Chicago and most of its suburbs is Lake Michigan. Although the intakes through which the water was drawn were located far from shore, and were being still further extended into the lake, it was decided that the only way to safeguard the water supply was to reverse the flow of the Chicago River. The quan-

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tity of water needed to attain this result in dry weather was small, but provision had to be made to maintain the reversal when the river was carrying storm water, and this requires a large quantity of water from Lake Michigan. Such diversion of lake water was and is the keynote of the success of the sanitary accomplishments of the project.

It is very likely that many critics of the Sanitary District of Chicago are not aware of the early history of sewerage in this section. For many years before the Main Drainage Canal was built, the city had been sending much of its sewage through the Chicago River and the Illinois and Michigan Canal into the Des Plaines River at Lockport. The old canal was built by the State under acts of Congress which did not limit the quantity of water that might be diverted from Lake Michigan through it. While the canal had been built as a waterway, no serious objection was raised to its further use as a channel for the removal of the diluted sewage of the city.

Topographical Advantage of Chicago's Situation

These early experiences of the city in sewage disposal by dilution and diversion into the Des Plaines River, by way of the I. and M. canal constructed by authority of Congress without any limitation by that body on its size or the quantity of water diverted through it from Lake Michigan, must be considered in connection with another condition. The question is sometimes asked, why should the Drainage Canal be permitted to take water from Lake Michigan to assist in disposing of the sewage of the Sanitary District when no other large city on the Great Lakes does anything of the sort. The answer to the question is that Chicago is the only lake city so favored by Nature that this is practicable. The South end of Lake Michigan is separated from the Des Plaines River by a ridge so low that formerly the flood waters of that river flowed over the lowest gap in the ridge and found their way into the lake. Through this gap the Illinois and Michigan Canal was cut, and by turning part of the sewage of the city into that canal it was kept out of the lake. It would have been short-sighted to have failed to take advantage of such a useful topographical condition under the then existing circumstances. These involved the necessity of protecting the city water supply, as well as providing suitable drainage and sewage disposal, at a time when the germ theory of disease and the art of water filtration were almost unknown.

The Drainage Canal

The Board of Engineers which, in 1887, recommended the construction of the Drainage Canal was particularly qualified for its task. Mr. Artingstall and Mr. Williams brought to the work an intimate knowledge of the history of the Chicago sewerage works and their operation. Dr. Hering not only had a practical acquaintance with the design and construction of sewers in large eastern cities, but was familiar through personal visits with the sewerage and sewage disposal works of the large cities of Great Britain and the Continent. These men studied the desirability of treating the sewage by chemical precipitation and also investigated the practicability of treating it by broad irrigation. These were the only methods of disposal then known, aside from disposal by dilution, and none of them had any economic advantage over dilution. It is significant that for over 20 years neither chemical precipitation nor broad irrigation has been utilized in this country to any material extent. Dilution, however, is used in disposing of the sewage without other treatment than preliminary screening, of 88 per cent of the population of American cities having a population of 100,000 or more in 1920. Looking at the problem after the lapse of years, it is hard to see any justification for any other decision in view of the experience to that date in discharging sewage into the Illinois and Michigan Canal, an artificial waterway into which an unlimited quantity of water could be admitted from Lake Michigan without further action by Congress.

The Drainage Canal was merely an enlarged edition to the Illinois and Michigan Canal, which it closely paralleled. It is hardly necessary to point out that it was less expensive to build an entirely new canal than enlarge the old one. It is interesting to consider, however, what would be the attitude of the critics of the Drainage Canal today, had the older canal been enlarged, as was apparently possible under the acts of Congress without any further applications for authority or for permits for the diversion of water. One of the chief features of controversy today over the Drainage Canal was unforeseen, in all probability, by Messrs. Hering, Artingstall and Williams, who undoubtedly believed that as the Drainage Canal was a substitute for the outgrown Illinois and Michigan Canal it had all the rights granted to the latter.

The Canal's Capacity

The 10,000 sec.-ft. capacity adopted was necessary to prevent the periodic discharge of the Chicago River into the lake with accompanying pollution of the water supply with the consequent epidemics.

It is unnecessary to go into any details of the Drainage Canal as built, for they are presumably familiar to most of you. The chief feature of the design bearing on this review of the canal problem is that the size of the canal was fixed to give it a capacity of 10,000 cubic feet per second.

Even as long ago as the early eighties, when the filth theory of transmission of disease prevailed, it was known that the sludge which had accumulated on the bottom of the sluggish river and the street refuse washed into the river by storms should be kept out of the lake. The only way to keep them out was to maintain a current from the lake into the river at all times. In 1924, with an average flow through the canal of 9,465 cubic feet per second, eight reversals occurred in the Chicago River during daylight hours, the longest lasting 22 minutes. While heavy storms can concentrate the discharge of the sewers at a maximum rate into the Chicago River in six hours, it requires more than twelve hours after opening the gates at Lockport before a low rate of flow can be increased from the Chicago River into the canal.

The Illinois statute under which the Drainage Canal was built did not fix the maximum size of the canal. It merely stipulated that it should carry at all times a flow of 3⅓ cubic feet per second per 1,000 persons draining into the canal.

Summing up the preceding review, it may be said that the designers of the Drainage Canal believed that no restriction existed upon the maximum quantity of water that could be diverted from the lake and they concluded that a diversion of 10,000 cubic feet per second would be necessary at times of flood to prevent the Chicago River from flowing into the lake. The canal was accordingly designed to have this capacity. It was not intended to maintain such a rate of flow at all times, but only enough to comply with the Illinois law requiring 3⅓ cubic feet per second per 1,000 persons. Its capacity, therefore, was that for a population of 3,000,000, although at the dilution rates stated in the 1887 report, 4 cubic feet per second per 1,000 population, it was projected for only 2,500,000.

Lock and Gate to Prevent River Reversal

It is desirable at this place to refer to an interesting suggestion that it would be practicable to prevent the flow of the Chicago River into the lake in times of high floods by building a lock and flood gate at the mouth of the river. It is hardly feasible, however, because if the flow through the canal were limited to 4,167 cubic feet per second, unusual storms producing flows in the sewers in excess of the permitted discharge of the canal would turn the river into an elongated storage reservoir and cause serious flooding of sewers, basements and streets as far as a mile back from the canal at some places. The Board of Review paid special attention to the desirability of this lock and flood-gate plan and was unable to endorse it for this locality on account of flooding. Heavy storms would cause the river

surface to rise 2 to 4 feet and sometimes much more, due to the gate. The low elevation of the most closely built-up parts of the District above the mean river surface makes this ponding a serious matter, and equivalent to depressing the surface of the ground to a corresponding distance. Such a dam is not necessary with a diversion of 10,000 cubic feet per second.

Canal Accomplishments

The Canal with its appurtenances has unquestionably served its purpose well in diverting sewage from the lake, and also up to the limits of its capacity in disposing of the ordinary sewage of this large district, and the sewage of industrial plants so charged with unstable organic matter and so large in volume that their disposal is a difficult matter. Local typhoid fever statistics speak volumes for diversion. It is helpful to consider the local industrial wastes in terms of the population furnishing a quantity of ordinary city sewage which contains an equivalent amount of organic matter, as measured by oxygen demands. For example, the population of the Sanitary District is now about 3,355,000 but the special industrial wastes mentioned are so difficult to treat that the sewage of the District, including these industrial sewages, is equivalent to the ordinary sewage from a community of nearly 4,900,000 population. This is more than 60 per cent above the 3,000,000 rated capacity according to the State Act of 1889, and nearly double the 2,500,000 capacity of the 1887 Commission. The latter made it's deductions from data which included but little influence of industrial wastes. Furthermore, it assumed that sludge would deposit near the mouth of the sewers and be removed by dredging.

Measures for Increased Disposal Facilities

The Canal had been in service only 5 or 6 years when the District applied for a permit to divert 4,000 cubic feet per second through the Calumet-Sag Canal to reverse the Calumet River, and to bring lake water to the lower end of the Main Canal to prevent putrefaction setting in there. This application, calling for 14,000 cubic feet of lake water in all, was denied in 1907. This Calumet-Sag Canal was built for 2,000 cubic feet per second capacity, with the quantity of lake water to be diverted to be settled by the courts, in accordance with arrangements made at a conference between the officers of the Sanitary District, the President of the United States and the Secretary of War.

In 1908, the District began extensive studies of different methods of sewage treatment with a view to designing plants having effluents requiring less diluting water than crude sewage and hence causing more desirable conditions in the Canal and the Des Plaines and Illinois Rivers. In spite of delays due to war conditions, a program for these works was completed in 1919. Two years later the Legislature authorized their execution at a stipulated rate of installation. About $30,000,000 has been spent on them already.

While the course followed by the Sanitary District in building these plants has not been that of the pioneer communities to make bold trials of novel processes, it has certainly kept abreast of all improvements in sewage treatment, it has itself contributed a large amount of valuable information to our knowledge of the subject through its experiments, and it has proceeded with the work with the caution shown by the careful business man. Its justification for this course has been its consistent belief that it had a right to divert 10,000 cubic feet per second of water from Lake Michigan if necessary, and its knowledge that the treatment works under construction would make it unnecessary to divert more water.

To appreciate circumstances as they gradually unfolded before the officers of the District, rather than to view them now in the light of hindsight, it is necessary to point out that the joint report of the Canadian and American members of the International Waterways Commission, dated May 3, 1906, recommended that diversions be limited on the Canadian side of the Great Lakes to

36,000 cubic feet per second and on the United States side to 18,500 cubic feet per second, and in addition thereto a diversion for sanitary purposes not to exceed 10,000 cubic feet per second be authorized for the Chicago Drainage Canal, and that a treaty or legislation be had limiting these diversions to the quantities mentioned.

In connection with the 1910 Treaty with Great Britain, it is interesting to note the following comments:

This treaty is silent as to the Chicago diversion but during its consideration by the United States Senate the Secretary of State, Elihu Root, appeared before the Senate Committee on Foreign Relations and stated in part as follows:

"The great bulk of the water goes on the Canadian side, and the waterways commission that was appointed some time ago to deal with the question of the lake levels reports, I think, that 36,000 feet can be taken out on the Canadian side and 18,500 on the American side without injury to the Falls. I thought it wise to follow the report of the commission and put in 1,500 feet in addition to get round numbers—so our limit is higher than we want, but their limit would not be cut down below what it is, because there are three companies on the Canadian side who have works there. Then there is this further fact why we could not object to this 36,000 cubic feet on the Canadian side. We are now taking 10,000 cubic feet per second out of Lake Michigan at Chicago, and I refused to permit them to say anything in the treaty about it. I would not permit them to say anything about Lake Michigan. I would not have anything in the treaty about it, and under the circumstances I thought it better not to kick about this 36,000. They consented to leave out of this treaty any reference to the drainage canal, and we are now taking 10,000 cubic feet per second for the drainage canal, which really comes out of this lake system." ("Proceedings of Foreign Relations Committee," 57-62d Congresses, pages 271-272.)

It is also of interest to note that Chandler P. Anderson, Esq., legal advisor of the State Department, during the consideration of this treaty, prepared a memorandum for the Senate Foreign Relations Committee, in which he stated:

"* * * Attention is called to the express provision in this article that it shall not apply to cases already existing which would seem to cover, and was certainly intended to cover, the Canal system at Chicago, * * * The treaty, therefore, recognizes that the settlement of the question of the use of waters of Lake Michigan is purely a domestic question and leaves undisturbed the governmental rights of the United States with respect to it."

Synopsis of Present Treatment Program

One of the major items of the work of the Board of Review which submitted its main report to the Sanitary District on December 20, 1924, and its technical report on January 23, 1925, was to examine the evidence and to pass upon a practical, efficient program for the actual requirements of sewage treatment as the situation stands today and as it will have to be faced during the next 20 to 25 years.

For more than three months this question was studied most energetically by a Committee consisting of Harrison P. Eddy, Chairman, Asa E. Phillips, Vice-Chairman, James H. Fuertes, John H. Gregory, T. Chalkley Hatton, Clarence W. Hubbell, and Anson Marston.

The recommended program of future construction for sewage treatment works and appurtenances, including the necessary interceptors and outfall sewers, consists of the following:

Des Plaines River Treatment Project, Activated Sludge Plant		$ 570,000
Calumet Sewage Treatment Project, Imhoff Tank—Trickling Filter Plant		5,061,000
North Side Sewage Treatment Project, Activated Sludge Plant		19,304,000
Corn Products Treatment Plant, Trickling Filter Plant	$ 2,919,000	
Stock Yards and Packingtown Plant, Activated Sludge Plant	11,096,000	14,015,000
West Side Sewage Treatment Project, Imhoff Tank Plant		25,261,000

Southwest Side Sewage Treatment Project, Imhoff Tank Plant 19,115,000

Miscellaneous Treatment Plants and Sewers, Imhoff Tank-Trickling Filter Plants 11,786,000

$95,112,000

This is spoken of in the report of the Board of Review as a $125,000,000 program, after inclusion of additional works required, with summary of items as follows:

Miscellaneous Works: Bridges, Highways and Settlement of Illinois Valley Overflow Claims $12,115,000

Contingent Projects, including Sanitary District's Share of Cost of Lake Level Regulating Works 14,648,000

Bond Discount 3,125,000

It was recommended that, subject to unavoidable delays, these projects be scheduled in the following order and be completed in the years stated:

North Side Sewage Treatment Project 1927

Corn Products Treatment Plant 1927

Stockyards and Packingtown Treatment Plant 1929

West Side Sewage Treatment Project 1934

Southwest Side Sewage Treatment Project 1939

The operations and maintenance of these projects are estimated to cost $4,613,000 per annum in 1945.

The above program for the future is substantially in accord with the 1919 program of the Sanitary District, which was founded on the results of more than 10 years of investigations with the local sewage and industrial wastes. It does not include about $30,000,000 of payments and commitments up to this date for intercepting sewers, conduits, pumping stations and treatment works, of which nearly $23,000,000 was spent before commencing the construction of the North Side Project.

Efforts to make arrangements with industrial interests for the joint installation of plants for the treatment of major industrial wastes did not work out satisfactorily. Accordingly their construction is included in the above mentioned program, and suits were filed in 1924 with a view to having a substantial part of the cost of construction and operation of plants for treating industrial wastes borne by the industries served.

So far as known, there is no controversy with the Federal authorities as to any essential features of the above mentioned program considered by the Sanitary District as requiring 20 years for its execution.

The Board of Review recognized that it may require 20 years for its construction but considered it desirable to complete the work earlier if practicable. Hence, it recommended that the construction period terminate in 1939 rather than 1945, as scheduled by the District.

This fully meets the views of the Army engineers who studied the matter in earlier years, as recognized in the decision of Judge Carpenter, United States District Judge, as follows:

"On the testimony of the Government engineers the court might, in the exercise of a sound discretion, delay the effectiveness of its injunction for from 15 to 25 years to enable the Sanitary District or the State of Illinois to arrange for other means of disposing of the sewage now handled by the Sanitary District."

Financing Program

It is essential to provide promptly and adequately for the financing of these sewage treatment projects. In order to do so the Board states that it is urgent to secure authority to increase the limit of bonded indebtedness from 3 to 5 per cent of the assessed valuation; and it is also urgent to increase adequately the minimum annual tax rate for administration, maintenance and operation. Funds received from the sale of bonds should be expended on new construction only, and all expenditures for administration, operation and main-

tenance, as well as for bond interest and bond redemption, should be paid from the annual tax levy.

Local Conditions

In order to appreciate the Chicago problem, it is necessary to recognize the individuality of local conditions, particularly the following:

(a) Practically all existing sewers are on the combined plan, which means that during storms it is impracticable to provide for storm flows to any substantial extent in either interceptors or treatment works. It would be very difficult and expensive to provide for a system of separate sewers for household wastes. Hence, during storms, practically all of the wastes of the city will continue to discharge into the Chicago River and its branches, since the treatment of the storm flows is impracticable.

(b) On the small watershed of the Chicago River there is concentrated a population now approximating 3,000,000 people and, including industrial wastes, the equivalent population is about 4,600,000. This population is still further increased if we include the shore line from Waukegan, Ill., to Michigan City, Ind., 82 miles. Here is a concentration of pollution at the lower end of Lake Michigan that is not approached elsewhere along the Great Lakes, not even at Milwaukee and Cleveland, the other large cities so located that they must discharge their sewage into the open lake opposite each of them and not into rivers which carry the sewage away from the water intakes.

(c) During the period required to build sewage treatment works and some 50 miles of intercepting sewers, there will be relatively large quantities of sewage matter in the canal system during dry weather. This is an item to be taken into account in connection with the preceding reference to the importance of insuring the reversal of flow of the Chicago River and the prevention of the discharge of large quantities of polluting matter into the lake.

(d) Velocities of flow in the canal have been too low to provide non-subsidizing velocities. In consequence substantial deposits of sludge have occurred. They decompose and make a heavy demand on the oxygen content of the overlying water, particularly during warm weather. Experience shows that to maintain comparative freedom from deposits, the velocity at no point should be less than 1.8 feet per second. In the earth section, without consideration of existing deposits, this velocity requires a flow of 10,000 cubic feet per second. With deposits left in place the corresponding volume is 8,750 cubic feet per second. Should the flow be reduced to 4,167 cubic feet per second the velocity in the earth section would become about 0.84 feet per second and in the rock section 1.08 feet per second.

(e) Attention may be here called again to the fact that this canal system is very materially overloaded, and that oxygen is practically absent during warm weather from the water in the lower end of the canal and in the river for many miles below Lockport. Practically the only diluting matter available in dry seasons is lake water, and the period of travel of the diluted sewage is so long that decomposition processes are carried, comparatively speaking, to an extent and for a period of duration seldom if ever found under conditions elsewhere in connection with the dilution method of sewage disposal.

Methods of Treatment

For the treatment of municipal sewage in plants yet to be put under contract, preliminary sedimentation in Imhoff tanks is proposed for the two principal plants, designated as the West Side and Southwest Side plants, to treat the sewage of the population between Fullerton Avenue and 87th Street. In order to secure a total removal of about 85 per cent of the organic matter, as measured by oxygen demand, trickling filters to treat the Imhoff tank effluents will be built ultimately.

In 1922 a special investigation was completed by Messrs. Eddy, Hatton and Fuller to determine whether trickling filters or the activated sludge process would be preferable at the North Side works, now under construction, for final treatment to make the removal of organic matter average about 85 per cent.

The activated sludge process was recommended because of the importance of guarding against the possibility of objectionable conditions arising in the immediate vicinity of Imhoff tanks and trickling filters large enough to serve a population of 800,000 people. It was further concluded that in view of the uncertainty of securing a market for the dried sludge; it would not then be wise for the Sanitary District to undertake to convert the activated sludge into commercial fertilizer. Consequently it was recommended that the wet sludge be pumped to lagoons on land now owned by the District between the Main Canal and the easterly dike of the Des Plaines River. Hence there were omitted for this large plant all debits and credits for drying and selling sludge. In the case of trickling filters a much larger area of land than usual at the particular site in question was provided for in the estimates in order to secure the isolation needed for such a large plant.

At the West Side and Southwest Side plants, adequate isolation for trickling filters can be secured without difficulty for supplementing the Imhoff tanks, which have 2.75 hours average detention period and a sludge chamber capacity of 2.3 cubic feet per capita.

Trickling filters were based on a rate of 3,000,000 gallons per acre daily on 6.5-foot beds of stone, corresponding to a loading of a little more than 2,000 persons per acre-foot.

The activated sludge process was based on preliminary settling tanks holding 30 minutes' flow; a 6-hour contact period in 15-foot aerating tanks; 20 per cent sludge in tanks, and one cubic foot of air per gallon of sewage. Secondary tanks have an average detention period of one hour.

Dilution Ratio

Much less lake water is needed in winter than in summer, because the lake water in cold wether carries about 50 per cent more atmospheric oxygen than in summer. Furthermore, accumulated deposits of sludge in the Canal decompose far more rapidly in warm than in cold weather.

The 8,500 cubic feet per second needed to prevent substantial deposition of sludge in the Canal will be ample for dilution during the winter months for some years to come.

In the summer the evidence now shows that the number of cubic feet per second required per 1,000 human population is 5 to 6.7; for 1,000 equivalent population, that is, including industrial and human wastes combined, 3.3 to 4.5. With the $125,000,000 program carried out by 1945 or earlier, there will be required a dilution of 2.1 cubic feet per 1,000 human population, and, in 1955, with supplementary works costing $35,000,000 completed, the figure becomes 0.7 cubic foot per second per 1,000 population.

Future Program

After the $125,000,000 program as above outlined, is completed it will be necessary ultimately to provide for complete treatment for a larger portion of the sewage than provided in these estimates. Various plants will need enlargement, and trickling filters will be required ultimately at both the Southwest Side and West Side plants. This supplementary program will involve an additional cost of at least $35,000,000, making a total for treatment works of $190,000,000, including the present $30,000,000 commitment.

Relation to City Water Supply

The Board took a strong stand in supporting the proposition of a progressive and effective program for restricting needless waste of the water supply of the City of Chicago including the installation of meters. Such a step would save the Sanitary District $5,000,000 in construction costs and large sums for operation.

It is the opinion of the Board that the City of Chicago will find it advisable, as have other cities on the Great Lakes, to build water purification plants within the next 15 to 20 years, thus securing additional protection against any pollution of its water supply by periodic river overflows from both the Chicago and Calumet Rivers and from lake

ships. The City, not the Sanitary District, must finance and carry out any filtration program since the latter has no legal jurisdiction over the water supply. This term of 15 to 20 years is approximately the time estimated for the construction of the sewage treatment plants in the program recommended for purifying the dry weather flow of raw sewage found in the canal and Chicago River, and subject to discharge into the Lake, were the flow to be materially reduced below 10,000 cubic feet per second. Furthermore, the installation of filters must be preceded by substantial results in reducing the gross waste, a program estimated to require 10 years.

Lakes-to-Gulf Waterway

What has been said so far relates solely to the local sanitary value of the Drainage Canal, but it has a national value as the most costly section of the Lakes-to-Gulf Waterway. A good many engineers regard barge canals and regulated rivers as unimportant means of transportation, which is not surprising in view of some criticisms of them in engineering publications. I wish those inclined to belittle inland waterways could have been with me on various occasions when I was watching the busy traffic on the waterways of France and Belgium, countries well provided with railways and excellent highways and consequently unlikely to utilize waterways were it not advantageous to do so. There was a time when our own canals were relatively far more important than they are now, but the railway superseded most of them, just as the electric interurban line is cutting into the local steam railway business, and the motor vehicles are now making a dent in the traffic of all their predecessors in the transportation field. It is well to keep in mind that while the motor truck is rapidly acquiring an important place as a transportation agency and is thus restoring the highway to something approaching its old distinction as one of the main arteries of our national life, the highway for motor trucking has to be a very different thing from the highway that served the purpose of the old coach. It is so with canals, and the Drainage Canal seems likely to become before long a link in an important inland waterway, for both the Federal government and the State of Illinois are working to that end. The latter has a $20,000,000 program under construction.

This is not the time for any extended discussion of inland waterways, but the possibilities of the Lakes-to-Gulf Waterway are too great to be left without a brief comment. There was a time when the traffic on the Ohio River, for instance, was unimportant. The Federal government then undertook the improvement of that river from Pittsburgh to Cairo, so as to give a 9-foot channel. These improvements have not yet been completed, but the work already done has resulted in an increase in the freight movement on the river which the 1923 Yearbook of the U. S. Depuartment of Commerce calls "striking." The tows of coal barges now using the river are types of the shipping facilities which are expected to make use of the Lakes-to-Gulf Waterway when it is opened, and are very different from the old-type canal boat. It has been estimated that 15,000,000 tons of coal will be shipped upbound into Chicago by this waterway at a large saving as compared to other means of transportation. Such tows are also used in shipping steel from Pittsburgh, and probably some of you have noticed the advertisements of Jones & Laughlin featuring such tows ready to leave their works with cargoes of steel for different cities along the Ohio and Mississippi. The steel barges built for similar use by subsidiaries of the United States Steel Corporation have also been illustrated in the engineering journals. It seems not unreasonable to expect that the Lakes-to-Gulf Waterway will be similarly utilized in shipping steel from the mills along the south end of Lake Michigan. The Government regulation of the Warrior River affords another instance of the development of a large freight movement by water, which is steadily increasing as the methods of making shipments in this way are improved and its advantages are more widely known.

Lowering of Lake Levels

The patent advantages of the Canal when operated in the light of modern engineering knowledge are offset by one disadvantage, and that is the fact that diversion of 10,000 cubic feet of water per second from Lake Michigan causes a lowering of the Lake levels not to exceed about 6 inches. This has been acknowledged by the Sanitary District and it has offered to pay its share of the cost of regulating works which will raise the level of the lakes not only to their elevation before the diversion, but much higher. No attention has been paid to this offer by the most vigorous critics of the Canal, the lake shipping interests, and some wonder has been expressed that these interests do not join hands with the District in backing the recommendation for the construction of the regulating works, which will produce far more beneficial results for them than the reduction of the quantity of water diverted from Lake Michigan by the Canal.

To understand the situation it is necessary to go back in the history of lake shipping. Originally boats having a deeper draft than 5 feet could not pass from Lake Huron to Lake Erie, and a portage had to be made from St. Mary's River into Lake Superior. As the shipping increased locks were built at Sault Ste. Marie, the shallow channels in and between the lakes were deepened and the harbors were improved. These betterments always lagged behind the demands of those ship owners who realized that transportation was accomplished most cheaply in vessels utilizing to the utmost the depth of water in the most shallow channels. The Federal Government provided channels having depths, successively, of 12 feet, 14 feet, 16 feet and 20 feet; and Canada is now providing channels 25 feet deep. Deepening of the channels to 30 feet is contemplated.

The ore carriers are the chief large freighters on the Great Lakes. A recent report stated that the Pittsburgh Steamship Company, a subsidiary of the U. S. Steel Corporation, owned 96 of these vessels, 50 were owned by Pickands, Mather & Co., 23 by the M. A. Hanna Co., and many more were owned by other steel interests. Such shipping records as I have been able to find in a superficial search show that as far back as 1916 naval architects laid down lake vessels with a molded depth of 27 to 30 feet. It is quite evident that the owners of boats built for a draft of 22 feet or more, and forced to operate them loaded to draw but 19 feet 8 inches, will urge the Government to restrict the diversion of water at Chicago to 4,167 cubic feet per second. It is probable that they are confident they can persuade the Government to regulate the levels of the Great Lakes and deepen the channels in and between the Lakes, without any assistance from the Sanitary District. If these guesses are correct, the attitude of these ship owners becomes a logical one, unless it be assumed they should be willing to consider the health and population along the south end of Lake Michigan and the utility of the Lakes-to-Gulf Waterway.

Lake Level Regulation

Depth of water in a channel can be obtained in two ways, by deepening the channel and by regulating the flow in such a way that the surplus water from storms is held back and admitted to the channel when dry weather would otherwise see a decrease in depth. The former method is that generally employed but the latter has been used successfully for eight years at the outlet of Lake Superior. The great advantage of the regulation of lake levels is that it equalizes the discharge of the lakes by taking advantage of the large storage capacity as compared with their discharge. By utilizing this storage capacity a considerable part of the large but slow flucuations in lake levels can be prevented and the average level can be raised 2 feet or more.

Nobody questions that the depth of water in the channels of the Great Lakes, where the depth is least and controls the draft of loaded ships, is now considerably below normal. The Board of Review has studied the causes of this reduced draft and is convinced that the diversion of water at Chicago has caused only 16 per cent of the reduction, instead of practically all of it, as charged by critics of the Drainage Canal. This is one of the

most important findings of the Board and deserves careful consideration.

Causes of Fluctuations in Levels

Fluctuations in lake levels are caused by many conditions. There are cycles five or more years long when the levels rise or fall, as these years have more or less than the average rainfall. Such cycles are familiar to all engineers who are acquainted with the conditions at reservoirs for water supply and irrigation, in which a large part of the stream flow of the rivers feeding them is stored. There is also a yearly cycle, the levels in summer being about one foot higher than in winter. Winds and changes in barometric pressure cause local daily fluctuations; one end of Lake Erie is sometimes 12 feet higher than the other on this account. There are irregular changes in the levels due to the deep freezing of tributaries and the St. Clair and Detroit Rivers in some years and not in others; ice jams materially affecting the discharge from Lake Huron into Lake Erie likewise occur in some years and not in others.

The causes of fluctuations just mentioned are beyond human control and not due to anything done by man. On the other hand, the dredging of the St. Clair to improve navigation and the scouring of the channel by the propellors of deep-draft vessels and by occasional ice jams have had an important permanent effect on lowering the levels of Lakes Huron and Michigan. The water diverted into the Welland, Erie and Drainage Canals has lowered all the lakes except Superior in varying amounts. As an offset to these causes of lower lake levels, there are the Gut dam in the Galop Rapids, which raises the level of Lake Ontario about 6 inches, and the regulating works at the foot of Lake Superior, raising the level of that lake 1 to 1½ feet but temporarily lowering the levels of the other lakes by withholding water.

In order that the quantitative effect of all these causes of fluctuating lake levels might be definitely pictured by anybody who desires to know all the facts relating to the influence of the Drainage Canal, the Board of Review made computations of the lowering of the levels that has caused the present total lowering of 31 inches in Lakes Michigan and Huron. The unusually light rainfall and unusually heavy evaporation during 1919-1923 inclusive have caused a lowering of 13 inches. The fall along the St. Clair and Detroit Rivers has averaged less of late than at earlier date and is responsible for 8 inches lowering. The diversion of water at Chicago has caused a lowering of 5 inches. The operation of the regulating works at the foot of Lake Superior by holding back water there is responsible for a lowering of 3 inches in the lakes below. Diversions of water from the Niagara River and Lake Erie have lowered that lake about 4.4 inches and the backwater effect of this fall has caused a lowering of 2 inches in Lakes Michigan and Huron.

It is customary for carriers of freight to decline responsibility for delays and destruction of property due to strikes, acts of God and other causes outside their control. So, following the practice of the lake shipping interests, who are the most severe critics of the Drainage Canal, the Board of Review has approved the policy of the Sanitary District in accepting responsibility for a lowering of Lakes Michigan and Huron amounting to 5 inches and declining to be held responsible for the lowering amounting to 26 inches, due to causes wholly outside its control.

Results of Regulation

Studies were made by the Board of Review to make certain of the practicability of regulating works at reasonable cost at suitable sites. As a result of all its investigations and studies it reached the conclusion that it is practicable, by means of regulating works at the outlets of Lakes Erie and Huron, with the existing works at the outlet of Lake Superior, to maintain under all ordinary conditions a minimum flow in the Niagara River of from 180,000 to 200,000 cubic feet per second, while also providing depths for navigation averaging two feet greater than those under the unregulated natural conditions prior to the Chicago diversion. With these regulating works, lake levels can be held fully as high with a 10,000 sec.-ft. diversion at Chicago as they can with that diversion absent.

Niagara Power

The regulation of the lake levels will

also be beneficial to the development of power on the Niagara and St. Lawrence Rivers. Treaties restrict the quantity of water which may be diverted from the Niagara River above the Falls and the available quantities set forth in the Treaty would be affected in no way by stopping the diversion of water at Chicago. Only one of the hydro-electric plants there uses all the available head; most of them utilize from two-fifths to two-thirds of the available fall. The total power developed on both sides of the river is only about two-thirds of what could be developed with the permissible quantities of water diverted and the full available head utilized. The Board of Review estimates that the present constant loss of power at Niagara through failure to use the net available head is over 500,000 continuous horse power. In view of this incomplete utilization of the water now diverted by Niagara hydro-electric companies and the further fact that only one-fourth of the total flow in the river is used for power purposes, the effect of the diversion at Chicago on the Niagara situation is plainly insignificant. The same is true of power development on the St. Lawrence River. A detailed examination of the possibilities for power development in the Niagara-St. Lawrence sections and the probable markets for this power led the Board of Review to conclude that no economic loss will result in these sections within fifty years from the diversion of 10,000 cubic feet of water at Chicago. In fact within this period of time and with the recommended regulation works provided, the Board has been unable to find any economic reason whatever for discontinuing the Chicago diversion.

Lockport Power Development

There is another aspect of the power problem which must be considered. The water flowing through the Drainage Canal develops power at Lockport, and by the time the treatment works which the Sanitary District has begun are completed to the extent recommended by the Board of Review more power will be needed than these works can supply. Furthermore, as power costs much more and is in greater demand in the Sanitary District than at Niagara there would be no economic waste in diverting 10,000 cubic feet per second, for power purposes exclusively, at Chicago rather than at Niagara. The subject was studied in detail by the Board of Review, which finally decided that under the conditions likely to prevail for a considerable period, a greater, more widespread economic use of the water power resources of the Great Lakes can be obtained if 10,000 cubic feet per second of Lake Michigan water is used in the Illinois Valley than if no such diversion is made. This is practical conservation.

Conclusion

The most important results of the studies of the Board of Review do not concern engineering but relate to economics. The Board summed up the chief engineering findings in the statement that the Drainage Canal afforded the wisest solution of the sewage disposal problem of the District at the time it was built and that instead of becoming obsolete its value to the District has increased and it is also a national asset as the most costly section of the Lakes-to-Gulf Waterway, soon to be an actuality.

The future requirements of Chicago as to sewage disposal demand faithful performance of the program set forth. In 15 to 20 years from now conditions can well be reviewed again. For the intervening period the Board of Review recommended:

> "That the District apply to the Federal authorities for permission to divert from Lake Michigan an annual average of 10,000 cubic feet per second of water as measured at Lockport, for sanitary and navigation purposes, until such time as a re-appraisal shall indicate that the most beneficial use of the waters of the Great Lakes requires a reconsideration of the amount of such diversion."

As a quasi-national undertaking affecting navigable waters, the Drainage Canal is, to some extent, under the Corps of Engineers, U. S. A., through the Secretary of War. The Federal statutes authorize the Corps to give due consideration to but part of the aspects of the canal problem. Some aspects come under

the cognizance of the Department of State. All aspects are so important and the organizations interested in them are so large that each of these organizations excepting the United States itself, is inevitably reluctant to invite the others to a conference, lest this be interpreted as a sign of weakness. As two Federal Executive Departments are already concerned, probably the most satisfactory way to reach an equitable program for the conservation of the Great Lakes is for the President of the United States to call all the principal parties involved into a conference on the subject. Whether this is feasible or not is not for me to say, but I wish to leave the thought with you that problems of this kind have been carried a long way toward solution when all concerned have agreed that there are certain things upon which they are in accord and have clearly stated the reasons for disagreement upon the remaining things. Time and mutual fair play generally indicate how to overcome these disagreements that seem insurmountable until it is shown how small a part of the whole each item of disagreement really is.

The Water Supply Problem In Relation to the Future Chicago

By JOHN ERICSON*, M. W. S. E.

Presented February 19, 1925

Chicago cannot continue its present method of furnishing water at a loss without assuming a staggering deficit as shown in this paper. Mr. Ericson gives a solution showing that water rates may be reduced and still earn a profit if meters are installed. The first announcement of a plan to build combined filter plants and recreation piers on the lake front is made here, but unless meters are installed this or any other plan for filtering Chicago's water will be prohibitive in cost.—Editor.

CHICAGO, the wonderful Queen City of the Great Lakes, that within the period of man's lifetime has grown from a village of a few hundred people to a metropolis with over three million inhabitants, from all indications has a destiny, the limits of which might be underestimated even by the most optimistic. Considering the past normal growth, there are unmistakable signs that within a very few decades the five million mark will be reached. Recently eminent students of sociology and urban and suburban life and development have made known the results of their studies of Chicago's probable future growth.

Professor Goode of the University of Chicago, a man of unusual ability, experience and grasp of such problems, after discussing the natural richness and advantages as regards topography, fertility of soil, building materials, coal fields, accessibility of unlimited iron ore fields, climate, transportation facilities, etc., of the large district, of which Chicago forms the center, believes that within a period of ten years this city will become a sea port, and that therewith those many other advantages will establish a new increase rate for this metropolitan center, which he expects to reach a population of from twelve to fifteen millions before the end of this century.

Professor William L. Bailey of Northwestern University, another student and authority on such matters, declares that Chicago is destined to be the greatest of all cities on the North American Continent within a comparatively few years.

When speaking of Chicago of the future, we must go beyond the present boundaries, for as the City in the past has increased in area by leaps and bounds, so it is also expected to do in future.

* City Engineer of Chicago.

The United States Census Bureau defines the metropolitan district, besides the city within its present limits, as an area lying within a radius of ten miles outside of the city's boundaries.

Another definition of the metropolitan district of Chicago by the Census Bureau, which includes six counties, namely, Cook, Lake, Kane, Du Page and Will Counties in Illinois and Lake County in Indiana, has also come to my notice.

This larger district included in the latter definition might be treated as a unit for census and certain other purposes, such as transportation, telephone, and other utilities, but by reason of the great distances of large parts of it from Lake Michigan—the present only practical source of water supply on a large scale—I shall not, as far as the water supply question is concerned, take into consideration these remote parts of this larger district, but will confine myself to that part located within practical water supply limits of Lake Michigan.

As regards Lake County, Indiana, where many fast growing cities are located at or within practical water supply limits of Lake Michigan and within comparatively short distances from each other, steps should be taken without unnecessary delay to create and organize sewerage and water supply districts, each embracing as much territory as may be found practicable to be served. Tunnels, pumping stations and other related construction could then be so designed and proportioned for each district as to meet the requirements of service in the most economical and practical manner.

The same may be said as regards the cities and villages located in the northern part of Cook and in Lake County, Illinois.

The cities in Kane, Du Page and Will Counties, Illinois, now all supplied from wells and springs, are too remote from Lake Michigan for a practical and economical supply of water from this source.

With the wonderful advances that are constantly being made by scientists in unfolding the secrets of nature in every direction, and the almost revolutionary effects on our civilization already experienced and surely to come; with the wizards in the laboratories breaking up atoms into electrons and determining their numbers and speed in various substances, which may lead to the upsetting of present accepted laws of nature, is it too visionary to assume that the time is not far away when new methods of purification of sewage and water supplies will make streams and water courses, that are now prohibited as such sources, entirely available at reasonable expense and easily within the financial resources of cities located on or within practical limits thereof? Then the Rock, Fox, Du Page and other rivers will be available as a supply for a number of such cities.

Personally, I believe that we are at the threshold of discoveries that will upset many of the theories and practices of our time, and, while we must plan for the future, it is not necessary to extend that future any longer than existing or now anticipated conditions seem to warrant or proper wisdom dictates.

For the present I shall, therefore, leave these districts, that are too remote from Lake Michigan for a supply therefrom and in which Chicago is not so directly interested, to depend on their wells and springs for their water supplies, until necessity more strongly indicates that a different solution is necessary.

There remain then to consider that part of Cook County embracing Chicago within its present limits and that part lying within the Sanitary District, including present or anticipated future extended boundaries, and which more nearly corresponds to the first definition of Metropolitan Chicago.

Growth in Population

The City of Chicago is growing at a phenomenal rate. For a considerable time it has been adding to its population fifty to sixty thousands or more every year. This increase is equivalent to absorbing into its present limits each year practically the populations of two of the now largest cities within the Chicago District, as above defined. It is equivalent to absorbing the entire population of the City of Peoria within one and a half years.

The population within the city limits today is estimated at three million people. The population of the Sanitary District

outside Chicago proper is about 300,000, and is increasing at a very rapid rate.

Based on the growth of population and on studies made by various authorities in the past, curves have been plotted and extended so as to indicate the probable population in 1960. Without considering any special influences that would accelerate the rate of increase, but considering only the natural trend of growth as based on the past, this curve indicates a population inside the City Limits in 1960 of about five million.

Some previous estimates of probable future population for Chicago made some years ago show the folowing results in 1950 and by extending the curves in each case I have also arrived at the estimates for 1960:

Greater Chicago, Including Suburban Area

	1950	1960
1. Illinois Bell Telephone Co. Estimate	5,770,000	6,500,000
2. Chicago Traction & Subway Commission	5,250,000	6,100,000

Inside Present City Limits Only

	1950	1960
3. Chicago Traction & Subway Commission	5,000,000	5,750,000
4. Association of Commerce	4,600,000	4,900,000
5. Illinois Bell Telephone Co.	4,207,000	4,800,000

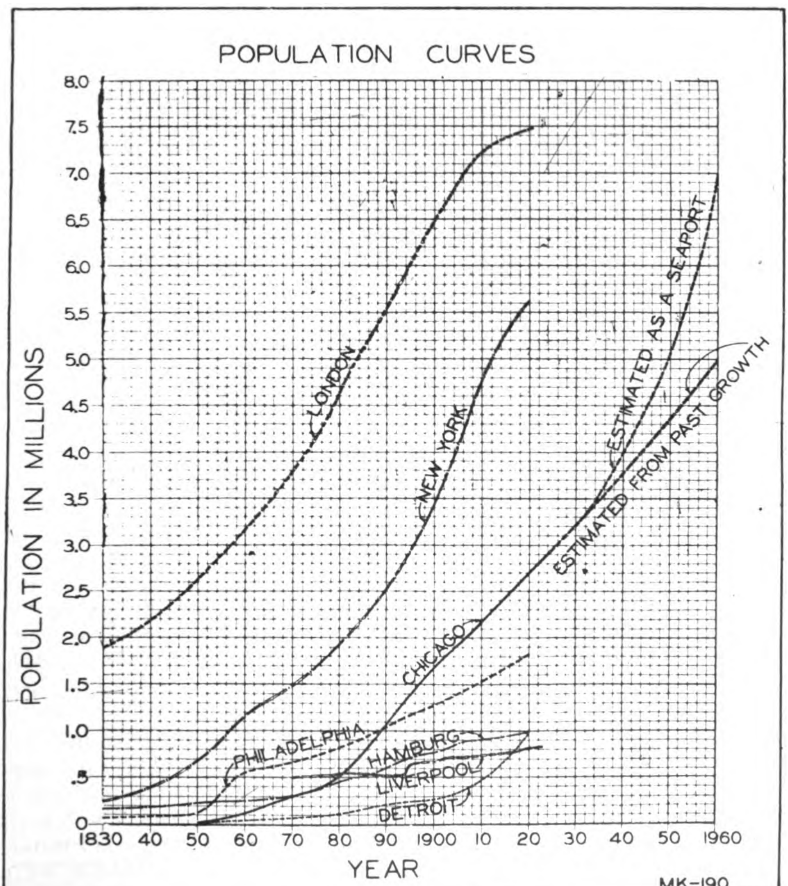


FIG. 1—COMPARING THE GROWTH OF CHICAGO'S POPULATION WITH OTHER CITIES.

The proposed harbor and consequent accelerated development of the Calumet District and the possible development of an Illiana harbor would have a marked influence on the future growth in population. Both these projects, not being such live issues when the former population curves were made, should now be taken into consideration, especially the Calumet Harbor, which will be an accomplished fact in the near future.

On the new population diagram accompanying this paper are also plotted the population curves of New York, London, Liverpool and some other large cities. All of these are more or less important sea port cities. If the predictions should come true that Chicago within ten years will also be a sea port city, and every indication is that it will, and if, as has been pointed out by eminent students of sociology, an accelerated growth in population will be the result thereof, it is not unreasonable to assume that the population curve of Chicago will take a course as indicated by the upper line of the diagram, which would more nearly follow the trend of the New York and London curves.

If this should be true, the population of the City of Chicago in 1960 would be about seven million. At my request Prof. Bailey has submitted an estimate of Chicago's population in 1960 within an 18-mile radius of the Loop. In the analysis accompanying his estimate Prof. Bailey goes pretty thoroughly into the tendency of urban and suburban movements in general, transient movements, changes in building and housing conditions, etc., and reaches the following conclusion:

"A greater Chicago of 12,000,000 in 1960 on the very modest basis of the 18-mile zone is reasonable and may well be much exceeded."

The Chicago Plan Commission in a memorandum on the population of Chicago, 1974, takes an even more optimistic view on this matter than does Prof. Bailey.

We will assume that in 1960 the city limits and the limits of the Sanitary District are about the same, comprising the area with the 18-mile circle, and no additional population outside such boundaries will be considered for the purpose of this article.

Chicago's Water Supply—Past, Present and Future

The growth and development of a community depend to a large extent on how the future needs are anticipated. We will assume that the transportation problem be satisfactorily solved within a few years.

The water supply question, which is the most important of all, will be discussed in this paper.

While for a large and growing community all public utilities are of great importance, there is none more vital than that of a wholesome and abundant water supply.

One could manage somehow without a transportation system; one could even manage to live with little or no artificial light, but without a reasonable pure and sufficient water supply stagnation and decadence would result. If this is true, then the water supply question should be given the foremost consideration and attention.

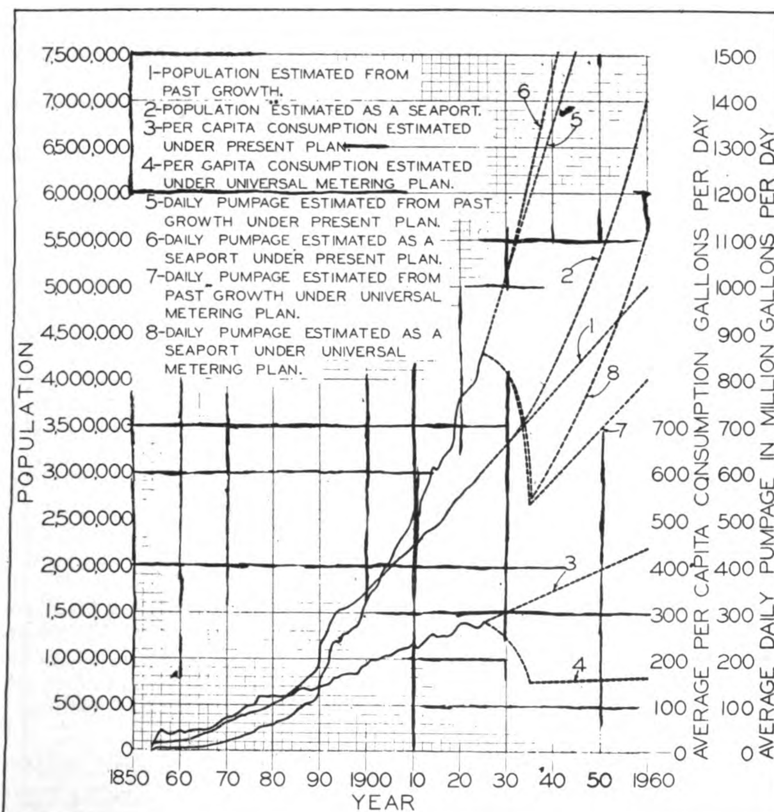
The past rapid growth of our City, with its frequent and extensive annexations of adjacent communities, with generally obsolete and inadequate water supply systems, and which had to be given immediate attention, has made the water supply problem, at least as far as furnishing the required quantities is concerned, a more or less difficult one at all times. This can better be realized when it is considered that the area of this city, in forty years' time, or during my own time of service in the Department, has increased from 36 to 205 square miles; the population from 640,000 to 3,000,000; the average daily pumpage from 80,000,000 to 845,000,000 gallons, and the average daily per-capita consumption from 125 to 280 gallons.

This rapid increase in the per-capita consumption as well as in population, has made continuous extensions and additions to the system necessary, and, notwithstanding these continuous activities and the expenditure of millions of dollars for this purpose alone, there has at no time been any real satisfac-

tory service, either as regards the quantity or the quality of the water, especially when considering the standards set by other large Lake cities and by the United States Government as regards such service.

In view of this situation, as far back as twenty-five years ago, I made as careful an investigation as conditions would then permit to ascertain what actual use was made of the great quantities of water pumped and what became of the excessive pumpage. These investigations convinced me that more than one-half of the pumpage served no useful purpose whatever, but was lost through plumbing and underground leaks, through wilful and other waste, and through slips in the pumps. This investigation also pointed to universal metering as the most practical remedy for this situation, and several reports and recommendations on this matter were presented.

The conclusive evidence of this waste and the practicability and effectiveness in other cities of the remedy suggested in said reports for Chicago seemed so sufficient and so convincing as to require immediate action by the executive and legislative branches of the City Government. The indifference, incredulity as regards the facts and almost hostility to the suggested measures were among the great surprises of my life. Regarding it as an imperative duty, irrespective of the reception that these first reports and recommendations received, I have consistently continued these investigations and recommendations. The



COMPARISON OF POPULATION AND PUMPAGE METERED AND UNMETERED.

reasons for this attitude on my part, I believe, will be made clear as we proceed. Some relief has been obtained through pitometer surveys with accompanying house inspections and the practical elimination of excessive losses caused by slippage in pumps and by reason of underground leakage.

The fact of the matter is, however, irrespective of the steps that have been taken to eliminate as much wastage and leaks as conditions would permit, that the per-capita consumption has been and is steadily increasing. This has been the cause of unsatisfactory service in the past, and points to a continuously increasing deficiency unless serious and immediate attention is given to the matter of metering the system or to the elimination of leaks and waste in some other way. The principal reason for this situation is that the City executives generally and the City Council in particular, have persistently failed to give any heed to repeated warnings or to act favorably on recommendations that have been made. Even sufficient funds for needed additions to meet requirements under the existing conditions have been denied not infrequently.

Several papers * on the subject of Water Supply and Metering have been presented by myself and others, and in this case therefore, I shall not take up any more time on the subject, except so far as it is necessary to show what effect a continuation of the present policy and the adoption of a universal metering policy will have on the service and on the growth of the City in the future.

By referring to the population curve and bearing in mind the prophesies of the authorities, hereinbefore mentioned, as well as of others as regards the anticipated growth of the City in the future, it can hardly be considered an exaggeration to assume that the population within the City Limits in 1960, as hereinbefore discussed, will have increased to seven millions.

Estimates of water service required for a population of five million people in 1960 have also been made. Comparison of results under the present meter policy continued and with a universal metering system for such a population and a population of seven million has been made and recorded in the attached tables.

Considering a population of seven millions and in conjunction therewith the indicated average per-capita consumption as shown on the diagram, a basis has been laid for estimating the quantity of water that Chicago should plan to furnish year by year up to and including 1960.

A per-capita consumption diagram prepared by me in 1905 and extended to 1921 proved exactly true in 1916, and correct within a few gallons in 1921. There are districts in Chicago where the average per-capita consumption is approximately 1000 gallons daily. Port Huron, Mich., is reported to have 400 gallons. The indicated 440 gallons for Chicago in 1960 cannot, therefore, be considered exaggerated.

The Sanitary District law, as now on the statute books, obligates the City of Chicago to furnish at its own limit a necessary water supply to any city or town located within the Sanitary District when application for such service has been made.

The City of Chicago at the present time is furnishing water to 26 cities and towns outside its limits, with a combined population of 221,000, in addition to supplying its own citizens. The quantity thus furnished in 1924 amounted to an average of about twenty million gallons daily.

The quantity furnished to these outside communities in 1924 would have been considerably increased if Chicago could have rendered the service required, but which, to its humiliation, it has been unable to do.

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* See Journal of the Western Society of Engineers.
The Water Works System of Chicago: J. H. Spengler, Vol. VI, p. 279, Aug. 1901.
Chicago Water Works: John Ericson, Vol. XVIII, p. 763, October 1913.
Water Supply of Cities: D. H. Maury, Vol. XXVIII, p. 125, April 1923.
The Chicago Water Works: M. B. Reynolds, Vol. XXVIII, p. 131, April 1923.
What Metering Would Do For The Chicago Water Works: L. R. Howson, Vol. XXVIII, p. 142, April 1923.
Report on Water Waste (Resolution) Vol. XXVIII, p. 114, June 1923.
An Improved Water Supply for Chicago and the Relation of Metering to Service: John Ericson, Vol. XIX, p. 371, Oct. 1924.
Metering the Water Supply of the City of Chicago; H. A. Allen, Vol. XIX, p. 379, Oct. 1924.

In order more clearly to set forth the greatness of the problems involved to meet adequately the situation as described herein, the following tables have been set up. From these tables, which show requirements for a five-million, as well as for a seven-million, population, it can be seen what capacities must be provided under the assumption that the present policy be permitted to prevail, and also what the results of a policy of universal metering are estimated to be.

These estimates are based on as careful analyses as can be made at this time, and are believed to be rather conservative.

The methods used in arriving at the results shown in the accompanying table were as follows:

In the 1925 data presented for comparisons, the per-capita pumpage and distribution were obtained from records in the Water Department, and are believed to be close to actual usage. The average per capita, total, and daily pumpage, etc., are based on the 1924 and previous records.

For future years the average per-capita consumption and the population were taken from the diagram. For totally metered system an average per-capita consumption of 160 gallons was used. This is believed to be a liberal allowance when compared with other metered cities. The average per-capita usages for various purposes are based on a careful study of conditions, past and present, and on the best combined judgment of those connected with Chicago's Water Department.

In estimating the sums of money required to be expended in the future for operation, maintenance, repairs and additions, unit costs were adopted, which were arrived at from a survey of past records and by applying the same with a consideration of estimated future conditions. This furnished a basis from which it is believed reasonable estimates could be made.

The cost of operation of the Water Works System, exclusive of interest charges and the cost of reading and maintaining meters, which are added separately, is obtained by multiplying the estimated number of million foot-gallons pumped per year by a factor of twenty cents, of which six and one-half cents and thirteen and one-half cents apply, respectively, to repairs and renewals, and to operation.

ESTIMATED WATER CONSUMPTION

	1925		1960				1960			
	Pop. 3,000,000		Population - 5,000,000				Population - 7,000,000			
Distribution	Present Metering Plan		Present Metering Plan		Universal Metering Plan		Present Metering Plan		Universal Metering Plan	
	M.G.D.	Gals. per Capita	M.G.D.	Gals. per Capita	M.G.D.	Gals. per Capita	M.G.D.	Gals. per Capita	M.G.D.	Gals. per Capita
Commercial and Industrial	165	55	305	61	305	61	427	61	427	61
Domestic, metered	59	20	150	30	375	75	210	30	525	75
Domestic, unmetered (legitimate)	120	40	225	45	–	–	315	45	–	–
Public, Religious, Educational and Charitable. (Free Water)	30	10	50	10	50	10	70	10	70	10
Parks and Boulevards (Free Water)	18	6	30	6	30	6	42	6	42	6
Underground street leakage, Slippage of Meters, Unaccountable	84	28	140	28	40	8	196	28	56	8
Plumbing Leakage, Wilful and unavoidable Waste.	364	121	1300	260	–	–	1820	260	–	–
Total average daily Pumpage	840	280	2200	440	800	160	3080	440	1120	160

A uniform head of 120 feet was used for the present plan for the entire period of 35 years, and 120 feet increasing uniformly to 150 feet in 1935 and continuing thereafter to 1960 for the metered plan.

Expenditures for additions to the system for the period 1925-1930 were used as already prepared by the Bureau of Engineering. Subsequent to 1930 a uniform factor of $40,000 per million gallons capacity for tunnels, cribs, pumping stations, and distributing system under maximum demand conditions, was used.

Under the present plan two million dollars per year were added after the year 1930 for miscellaneous extensions and betterments to the system as a whole.

The average cost of installing meters was taken at $30.00 per meter; the cost of reading and maintaining meters was taken as $2.00 and $2.50, respectively, or a yearly charge for these purposes of $4.50.

The revenue was obtained by projecting the past and present trend for the unmetered system and increasing it in the ratio of 7 to 5 for a seven-million population in 1960.

The revenue under a metered system was taken from estimates, which were carefully made about a year ago by Col. Allen of the City Engineer's staff.

The Outlook for the Future

The present nominal pumping capacity is about 1100 and the present tunnel capacity about 1600 million gallons per day. This tunnel capacity could be considerably increased under conditions to be mentioned later. Referring to the foregoing tabulation it will be seen that, if the larger estimate for the growth in population should prove true and if the present metering policy is continued, the City must adopt a construction program that will bring the nominal pumping capacity in 1960 to 4600 million gallons per day to meet maximum demands, estimating maximum demands at only 150% of average demands. This is equivalent to a pumping capacity of over four times the capacity of the present system. These required additions to the present system, including tunnels, pumping stations, cribs, mains, etc., and also operation and maintenance, are estimated to aggregate an expenditure of $790,000,000.

This estimate includes the cost of the Western Avenue System now under construction, but does not include any expenditures for filter plants.

Assuming further that the water rates remain the same as at present, the estimated aggregate revenues during this same period are $712,000,000. This shows a loss to the Water Department alone of $78,000,000.

If the population in 1960 should increase to only five millions, the loss would still be $67,000,000.00.

This indicates that in either case a readjustment of rates would be necessary at once in order to keep the system on a sound financial basis.

In these losses are not included other great ones to the Sanitary District, which has to expend many millions of dollars additional in constructions and operation of sewage treatment plants, on account of the excessive pumpage of water and which otherwise would not have to be done.

During the twenty years from 1884 to 1904 the nominal daily pumping capacity was increased by 255 million gallons or at an average rate of about 13 million gallons daily capacity each year. During the period from 1904 to 1924 this average increase each year was at a rate of 37 million gallons daily capacity. This extensive activity has taxed the physical, as well as the financial, resources of the city to the limit. If the existing policy should be permitted to continue and the larger estimated growth of the City come true, there will have to be 3500 million gallons added to the present daily pumping capacity of 1100 million gallons, or at an average rate of 100 million gallons daily capacity each year during the next 35 years. In addition to the pumping capacity, very extensive tunnel and pumping station constructions, as well as many miles of large mains, would be required.

It seems very doubtful, to say the

least, that the city would be able to carry out any such extensive construction program. Even could this be done, a maximum head of about 120 feet at the stations is all that could be expected.

With a universal metering system the accumulated surplus revenue in the case of a 7,000,000 population in 1960 would be $151,000,000. Should the population reach only 5,000,000 the accumulated surplus would be $131,000,000.

With this showing it seems inconceivable that such an absurd policy should be continued, and therefore, I have not made an attempt at this time to outline any plans, whereby such conditions as above related could be met for the long period under consideration.

A thorough survey is now being made by the Bureau of Engineering for the purpose of finding how such a large additional system could be designed.

It is therefore, herein assumed that universal metering, as an absolute necessity, will be the adopted policy without further delay, if the City's growth is not to be seriously retarded.

With universal metering, if inaugurated at once and brought to full effect in ten years, and the system kept wholly metered thereafter, the nominal maximum capacity required in 1960 would be only 1680 million gallons daily, the average daily consumption being 1120 million gallons. The head could then readily be increased to 150 feet which would insure ample pressures in all parts of the district.

The present tunnel capacity of 1600 million gallons per day, and which would nearly meet these requirements, can be considerably increased if filter plants are constructed as hereinafter shown. To utilize this capacity for increased pumpage involves simply the replacing of the older or smaller pumps with pumps of larger capacity, which, since the adoption of centrifugal pumps for water supply purposes, would require no extensive alterations to buildings, as they require so much less space than reciprocating pumping engines. It must be borne in mind also that there is now under construction a new pumping station (the Western Avenue plant), with a nominal maximum pumping capacity of 300 million gallons per day. A new tunnel in Chicago Avenue extending westward to the city limits, or farther when necessary, has been authorized. This tunnel will be supplied through a 13-foot tunnel, which will form a branch of the 16-foot tunnel now being constructed as an extension lakeward of the three old tunnels, terminating at the Two mile Crib off Chicago Avenue.

This proposed Chicago Avenue Tunnel, through branch tunnels extending north and south from the same to Springfield Avenue and Central Park

REVENUE AND EXPENSE 1925 TO 1960

	POPULATION-5,000,000		POPULATION-7,000,000	
	Present Metering Plan	Universal Metering Plan	Present Metering Plan	Universal Metering Plan
Total Revenue	$557,000,000	$452,000,000	$712,000,000	$555,000,000
Operation	$310,000,000	$193,000,000	$390,000,000	$240,000,000
Repairs and Renewals	$150,000,000	$107,000,000	$190,000,000	$134,000,000
Additions and Extensions	$164,000,000	$21,000,000	$210,000,000	$30,000,000
Total Expenditures	$624,000,000	$321,000,000	$790,000,000	$404,000,000
Excess Expenditures	$67,000,000		$78,000,000	
Surplus Revenue		$131,000,000		$151,000,000

Avenue Pumping Stations, respectively, would increase the capacity at each of these stations from 120 to 220 million gallons per day, and still furnish a surplus capacity of 200 million gallons per day for a future pumping station or stations, to be located in the western part of metropolitan Chicago.

Provisions for the extension of existing tunnels have also been made at the western terminus of the Western Avenue Tunnel at 73rd Street; at Bond Avenue and 73rd Street for a tunnel leading south to the South Chicago District; and at Lincoln Avenue, Lawndale Avenue and western terminus on the Wilson Avenue Tunnel. Such extensions can be made readily to supply additional stations as may be necessary in the future for serving such areas in the metropolitan district that existing or authorized stations cannot reach economically.

With a fully metered system the city, therefore, has a clearly defined tunnel and pumping station layout, which requires only the carrying out of the construction of some tunnel extensions and pumping stations as needed to supply the entire Metropolitan District up to 1960 and beyond. In fact, with the completion of the Western Avenue System and without considering the proposed Chicago Avenue Tunnel, there will be sufficient capacity to supply Greater Chicago until 1960, or an estimated population of seven million at an additional expense, taking cost of metering into account, of about $30,000,000.

Quality of the Water Supply

Previous to the opening of the Drainage Canal the quality of the Water Supply was unsatisfactory to an alarming degree. In 1887, while in the employ of the Chicago Drainage and Water Supply Commission, after a flood, I personally traced and located polluted water, almost black, that entirely enveloped the then only intake crib.

The death rate from water born diseases was approaching 200 per 100,000 inhabitants.

The wonderful change in this situation, caused by the work of the Sanitary District in the completion and opening of the Drainage Canal, can hardly be appreciated by the average citizen.

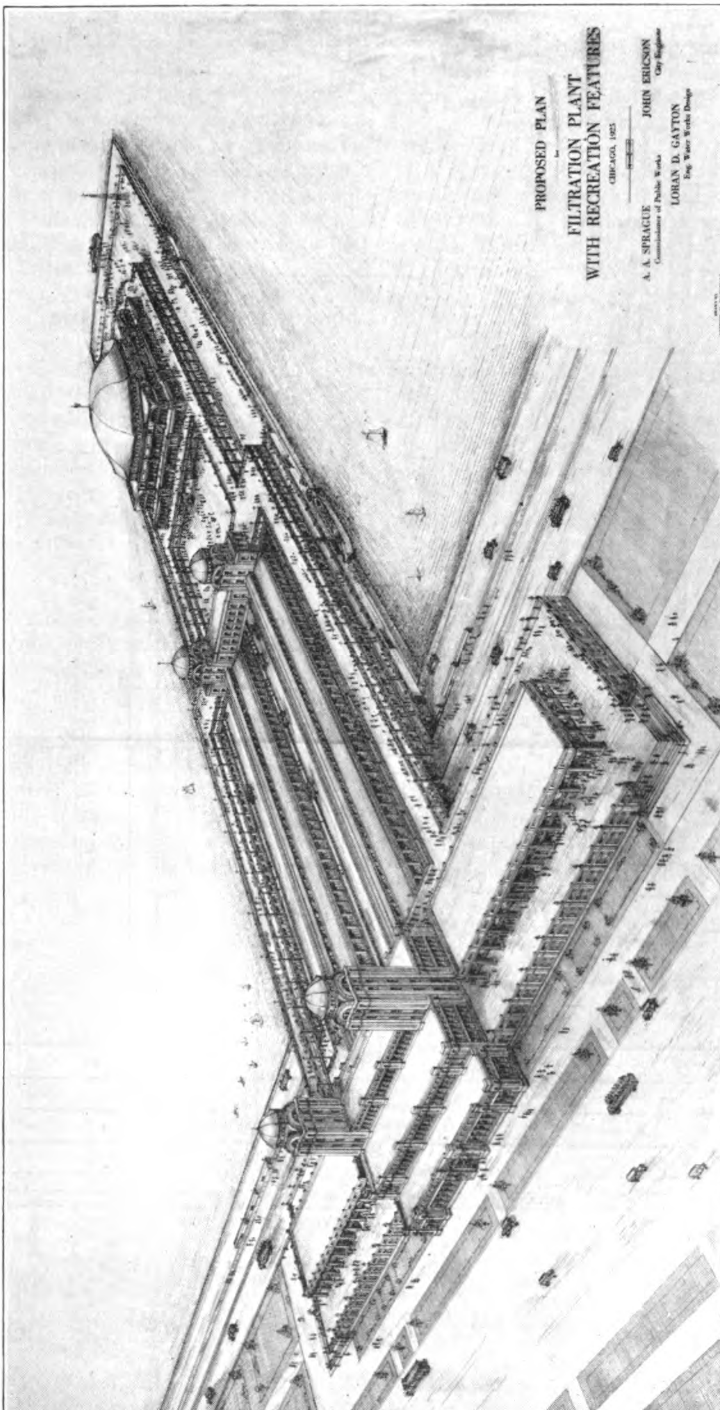
Gradually, however, it became evident that the effect of the Drainage Canal alone was not at all times sufficient to safeguard our water supply from objectionable and even dangerous pollution. With the rapid increase in population, with other growing communites located around the lower end of Lake Michigan discharging their raw sewage into the lake, with occasional reversal of flow of the Chicago and Calumet Rivers after storms and with shipping and dumping in some degree adding to the pollution of the water, it became necessary to introduce chlorine to minimize as far as possible the danger lurking in the water supply.

The doses of chlorine have gradually been ordered increased by the Health Department to such an extent, especially during the past year, that if continued will soon bring about a question of the practicability of depending entirely on this method of purification.

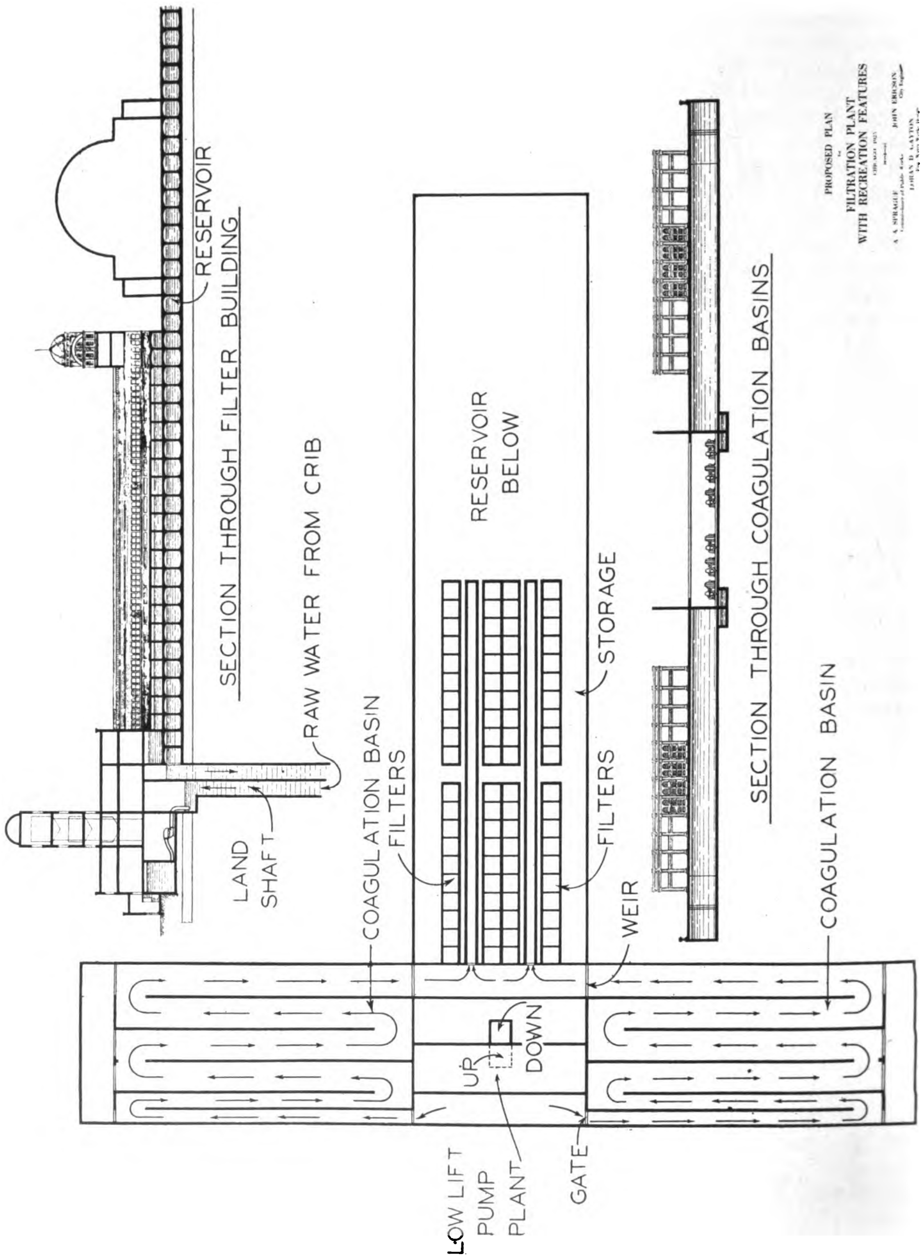
Thus the 675,000 pounds of chlorine used in 1923 to disinfect the water supply were in 1924 increased to 1,250,800 pounds.

The conclusion that chlorine in very minute quantities is required by, and is not injurious to, the human body may be drawn from the fact that nature has produced common salt or sodium chloride, which both animals and humans are known to require. Chlorine as a disinfectant of water, however, has not been commonly used more than a comparatively few years.

We all know the destructive effect on common metals by free, moist chlorine, even in such small quantities as will be found in the treated water. While there may not yet have been noticed any particularly bad effect generally from this chemical thus taken into the system, if there is anyone who can state authoritatively that the very delicate tissues of the human organisms will not be affected in say 20 or 30 years or less, if quantities used have to be steadily increased, he should make such a fact known as quickly as possible, for there



SUGGESTED FILTER PLANT LOCATED AT THE LAKE SHORE WHERE RECREATION FEATURES WOULD BE COMBINED.



SECTION AND PLAN OF A COMBINED FILTER PLANT AND RECREATION PIER.

are many that are dubious, if not apprehensive, about this matter.

The citizens of Chicago are entitled to a clear and wholesome, as well as an adequate, water supply at all times. Sewage purification plants now under construction and contemplated by the Sanitary District will further tend to improve conditions for purity, but, notwithstanding these additional efforts on the part of our community, there will still remain the turbidity and occasional pollution from one source or another.

Health officers and sanitary engineers generally advocate filtration as the best and most desirable method of purifying and clarifying water.

Why then has not Chicago installed filters in connection with its water supply long ago? Experts, engaged many years ago by the City to find and recommend a solution of the quality problem of the water supply recommended the construction of the Drainage Canal to reverse the flow in the Chicago River and thus keep its sewage-laden waters from flowing into the Lake. Later when it was found that this did not eliminate all the trouble there was a financial impractibility to construct such plants, owing to the staggering capacities required on account of the reckless and steadily increasing waste and leakage in the water supply system.

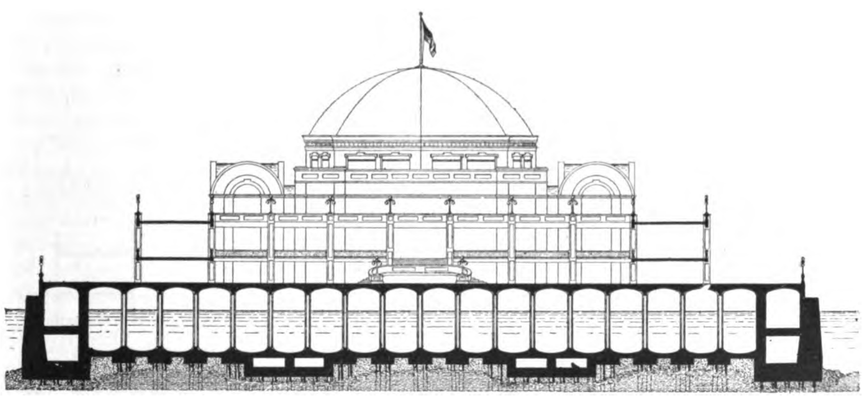
Some years after presenting my first reports on this abnormal waste and my recommendations for conserving the water supply, and believing in my own mind that a universal metering policy could not be long delayed, and further realizing that demands for filtered water would be made soon thereafter, I submitted a communication to the then Commissioner of Public Works on this subject.

In this communication I recommended that proper steps be taken for a preliminary study and investigation with a view of outlining a plan for filter construction and the early inauguration of an experimental plant for learning the best method of filtration under our Chicago conditions. This suggestion, however, was not favorably received.

The succeeding administration was so openly and strongly opposed to metering of the water supply that any further suggestions or recommendations as regards either meters or filters were out of the question.

Since the summer of 1923, with the coming of the present administration into power, the question of metering and filtration has again come to the fore, and has been given a great deal of consideration.

Arthur E. Gorman, Chief Sanitary Engineer, Chicago Health Department, in a recent article states that the water supply of Chicago is becoming more and more potentially dangerous and that the in-



CROSS SECTION THROUGH FILTERED WATER RESERVOIR

AND

RECREATION BUILDING

creasing quantities of chlorine required for disinfecting purposes will render it quite objectionable for drinking purposes.

Filtration of the Chicago water supply is, therefore, rapidly becoming a very important matter.

In a preliminary investigation of the filtering proposition recently completed, several serious obstacles to a proper solution of this important problem were found.

The properties adjacent to our various pumping stations have been covered with costly buildings and the property values have increased to such an extent that now to secure the necessary land for filtration plants adjacent to the stations is almost beyond the Department's financial reach. Because of the many stations in the system, this difficulty is increased.

Consideration has, therefore, been given to the possibility and practicability of locating filter plants at or adjacent to the Lake Shore, with a view of connecting the same to the main tunnels where these intersect with the shore line. This would reduce the number of such plants by over fifty per cent.

The difficulty with this plan is the problem of connecting up the old tunnels to the filters, and the possibility of contamination of the filtered water between the filter plant and the pumping stations, where such are located remote from the Lake. In the event of universal metering the first objection may be less difficult. As regards the second objection it may be stated that seepage of polluted water into the tunnels is believed to occur only at the shafts. A thorough examination and repairing of shafts are contemplated for this year.

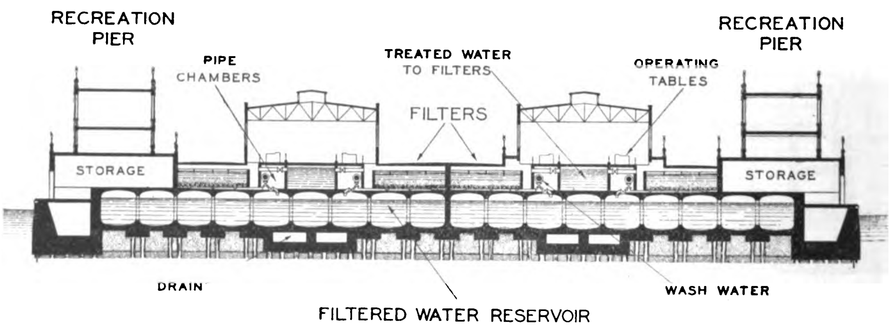
Filter plants in connection with new tunnels will meet with no such construction difficulties.

Without any pretense of having gone into this matter of filter plants in critical detail so as to speak at this time authoritatively on the matter, some study drawings have been prepared, and are herewith presented, showing a possibly advantageous solution of the problem. The idea is to combine such plants with recreation piers as an incidental feature, extending from shore a suitable distance out into the lake. The recreation part of the plants would undoubtedly be a desirable asset to our future metropolis, and if this suggestion is proved practical these recreation features could be obtained without any great additional cost, thus benefitting both the Water Fund and the General Fund.

The plans for a typical plant herewith presented, and showing the placing of the entire or part of the filter plant in a pier, extending out into the lake, represent an idea rather than an actually suggested form of construction. Where land can be obtained at or close to the lake shore and conditions are otherwise favorable, part or even all of the plant may be placed on land.

There is much elasticity possible in the layout of these plants, so that the pier part with its recreation features

Editor's Note—See Mr. Gorman's subsequent paper in this issue.



CROSS SECTION THROUGH FILTER BUILDING

can be made as short or as long or of such shape as may be most practical or desirable at each particular location.

In designing filter plants the head on the clear water tunnels can be increased and thus the tunnel capacity increased also without any lowering of pumps.

Without a universal metering system, filter plants, as generally constructed and developed to date, would be *beyond the City's practical finances.*

Super Tunnels

The question of extending the lake tunnels to points beyond any danger of pollution or the absence of turbidity has also been considered.

It has been found that wave action affects water in Lake Michigan to a depth of 50 to 60 feet. To reach such depths at intakes the tunnels would have to be extended to points 10 miles or more from shore. Even then there would be no absolute assurance of a pure and uncontaminated water supply at all times.

When considering the great difficulties and cost of such an undertaking it also appears to be beyond the point of practicability.

Conclusion

The present policy, necessitating the pumping of large quantities of water beyond the possible need of the people, should not and cannot be continued, and the city follow an otherwise natural and anticipated trend of expansion or enjoy an adequate and up-to-date water supply.

With the adoption and introduction of a universal metering system, there is already available sufficient tunnel and pumping capacity to supply Chicago and adjoining cities with an ample supply of water for many years. With the completion of plants now under construction and authorized, the city, without any considerable additional expense, can easily supply a population of seven million people.

The saving in money by eliminating the preventable leakage and waste of water will be sufficient to defray all necessary expenses for operation and needed additions, as well as for the construction and operation of filter plants, and still permit a lowering of rates or leave a considerable surplus.

DISCUSSION

M. B. Reynolds: It might be more interesting to discuss what the condition of the Water Works might be today if the recommendations made by Mr. Ericson in 1905 and earlier had been accepted and acted upon, rather than to discuss the subject matter of his present paper.

If a complete metering program had been started in 1907 and finished in 1913, no expenditure for additional capacity would have been necessary until 1917. In the same interval $17,000,000 were spent for additions and betterments, seven millions of which would most likely have been expended in the operation of any plan. Adjusting in the case of a completely metered system for the cost of operation and repair, and also allowing a liberal estimate for the cost of metering, it would seem very probable that at the end of 1913 the system could have been completely metered, and there would have been accruing an annual surplus of between $750,000 and $1,000,000.

It, also, seems very probable that immediately thereafter a program for filtration could have been adopted and practically completed by the present time. Such a plant would have cost approximately $10,000,000. At the same time a considerable saving would have been realized by those paying frontage rates.

That metering and in turn filtration will eventually come, there can be no doubt. The reason that the advantage of such a plant is not being enjoyed today is because those best qualified to know what is right are not empowered to act. The present Commissioner of Public Works and the Mayor advocate meters. The adoption of the policy, however, remains with the City Council, and when the matter is presented there, no action is taken. Under these conditions the people themselves are the ones to demand action most favorable to their welfare, but to do this they must first be educated in the advantages.

It took many years to obtain the Drainage Canal. Many, even city executives, looked upon the lake as the most convenient and economical place to dump the sewage, and the most unbearable conditions were tolerated.

With the advance in all ways of the standard of living, it would seem that the present situation is about the same for present day standards as the conditions prior to 1900 were to the standards of that day.

The warnings of the City Engineer should be heeded now, and a real effort made to plan for a water supply suitable both in economic and aesthetic considerations.

Langdon Pearse: I think Mr. Ericson and the other gentlemen in the City Hall seemed to rather overlook, if I don't misunderstand Mr. Ericson's diagrams and tables, the fact that if they are going ahead with the water works on the present basis they have to raise the water rates, because as I understand it, they have practically reached the limit of bonding power at the present time. If that is the case, and these tables are correct, I don't see why that argument is not used instead of talking about meters and the like as strongly as they have done. Bring out the fact that you have got to raise your water rates in order to better the water supply and improve your pumping capacity and other things. It certainly is a very important feature and it is one that at least in print has not been sufficiently stressed, it seems to me.

I know Mr. Ericson is very busy and this is just a thought, but it does seem to me in the perspective of this paper that one of the very important things that could have been brought out is that water rates are going to be raised if they are going to continue in business, and if I am not mistaken in a paper some months ago Mr. Ericson brought out the fact that at present there is a deficit in the annual operation. So there is a very strong need either for revision of water rates or some financial program that will help, and that may serve as a club to bring about meters which will be better than direct propaganda. As a rule the money end of these things counts even more than the aesthetics. I have often found that to be the case.

The next point Mr. Ericson brought up was the question of efficacy of chlorine in filtration. I think that it has long been evident to those of us watching the operations of other cities in the neighborhood of Chicago that chlorine in itself should not be considered as a permanent means of treatment where you have much pollution to cope with. It is very good where you have constant quality of raw water, but under the varying conditions of the lake cities, such as Chicago, in the southern end of the Calumet District, and also some of the Calumet towns, chlorine does not appear to be a permanent solution. It has long been evident to me, perhaps as long as twelve years ago, that something might have to be done with filtration, certainly on the southern cribs, long before the northern cribs would require it, and I think, while I have not reviewed the data accumulated in the last few months, that it will be borne out by a study of the water of the lake that as you go north from the Chicago River the conditions of the raw water are vastly improved, so that chlorine is merely a very good temporary means of protecting the water supply. Where there is variable raw water there must be a filter plant, in order to make a constant medium to dose, because it is very difficult to know how to apply the chlorine and apply it rightly, to meet the pollution at every moment.

I think Mr. Ericson's suggestion of grouping the filter plants so as to connect with the tunnels is a very sound one. It appeared to me the only practical solution of the problem here and judging by the experience of other lake cities in building on the water front, there should be no great difficulty eventually in building a plant on the water front. We have the example in Milwaukee of a very successful coffer dam, probably the largest ever put together, with steel piling, and a plant built in the water, which would be a similar type of construction to what would be needed here.

The cost of filtration I think has perhaps been put a little low in this paper,

judging by the experience that some of us have had in work of that type in Chicago, but that may do no harm at the present juncture, because it does clearly illustrate that the metering would not only pay for the meters in the savings produced, but would also pay for the filtration. Comparing the figures that Mr. Ericson gave of deficits and profits, and I understand that is without changing the rates, not only would profits made by putting in meters pay for the filter plants, but also they would pay for the meters, so that metering could be had at least on those tables, without cost to the community, and with a profit beside in the way of actual cash in the bank. That is a very important feature of that tabulation, it seems to me.

Some Public Health Engineering Problems in Chicago

By Arthur E. Gorman*

Presented February 19, 1925

Although purity of the water supply is one of the most important matters engaging the attention of a public health officer there are many other things that must be taken into consideration. Spread of disease from other sources such as bathing beaches, swimming pools, mosquitoes, rats, etc., must be prevented. The paper given here points these out. The need for a comprehensive survey of the health situation should be more strongly emphasized.—Editor.

ON THE second day of this century engineering skill wrote into the health annals of Chicago a lifesaving policy which has brought remarkable dividends. The opening of the Drainage Canal on that day; the installation of the South and North Side intercepting sewers in 1906 and 1908 respectively, and the use of chlorine for disinfecting the public water supply in 1916 is a series of engineering attainments which have been largely responsible for Chicago overcoming the ill name of being a typhoid city and attaining the reputation of having the lowest typhoid rate of any large city in the United States.

Now at the quarter turn of the century Chicago faces other public health engineering problems which must and will be solved to give this municipality its ranking place as the nation's greatest city to be. At other sessions of these convocation meetings you shall learn of plans for water supply and sewerage developments. This paper will, therefore, be limited to a brief discussion of some of the other health engineering problems which must be given careful study and consideration, even though in the meantime their importance in the public mind may be eclipsed by the magnitude of the water supply and sewerage program.

Chlorination Control

While ways and means are being found for metering water and installing water filtration plants, a program for efficient and effective supervision over chlorination of the public water supply must be developed and enforced. Whether the Sanitary District has permission to withdraw 1,000 or 10,000 cubic feet per second of water from Lake Michigan for sewage dilution purposes, as long as the present water system in Chicago is used chlorination will continue to be the first line of defense against a potentially dangerous water supply. Approximately 3,000 pounds of this chemical are required each day to render the 800,000,000 gallons of water

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pumped, safe for human consumption. It is obvious that this important work should be carefully supervised. Since chlorination is the only factor of safety in our water supply control, careful studies of conditions affecting the sanitary quality of the lake water in the vicinity of intake cribs must be made.

Sources of Lake Pollution

There are two sources of pollution which are of special importance:

1. The Calumet River.
2. Lake front improvement work.

The Calumet River is a serious source of pollution of the lake waters, particularly in the areas surrounding the 68th street and Dunne cribs. It disharges into the lake more often than is generally realized. From reports received from bridge tenders at the 92nd street bridge this river appeared to flow eastward 132½ days out of the 315 days when observations were made during 1924, or 42 per cent of the time. During November and December it flowed eastward 45½ days, or 74.5 per cent of the time.

Not only does this river contaminate the lake by sewage, but it pollutes these waters with industrial wastes which at certain times impart very disagreeable tastes to the drinking water. On two occasions during the last two months industrial wastes so polluted the waters taken in at the 68th street and Dunne cribs that the normal quantities of chlorine used for disinfection were completely absorbed making it necessary to dose with excessively high mounts of this chemical for safety purposes. There is need for a very careful study of the industrial wastes which are discharged into the Calumet River, for irrespective of the installation of filtration plants, taste and odor difficulties are liable to be experienced as long as these causative factors exist.

Chicago's lake front park development program is a peerless one. However, judging from the effect which these activities have already had on the sanitary quality of the lake waters in the vicinity of the working areas, the zone surrounding the 68th street and Dunne cribs will probably become more and more polluted as the lake front project continues southward. The average B. coli contours showing the degree of contamination of Lake Michigan off Chicago and drawn from the results of bacterial analyses of 1173 samples collected from July to December, 1924, from selected points, show a definite zone of heavy pollution in the areas just west of the dumping and dredging activities carried out in connection with the south park work off 12th to 16th streets. Unless filtration is provided for before this south park program is completed it is doubtful if chlorination can be depended on for safeguarding the public water supply obtained from these two cribs. It is certain that under the conditions likely to be met the quantity of chlorine necessary for disinfecting the water will render it quite objectionable for drinking purposes.

Another source of pollution which will become acute if this city becomes a world port is the contamination of the lake waters by sewage discharged from vessels. At the present time shipping into this port is relatively light and this problem is not one of magnitude. However, with scores of foreign vessels arriving and departing from this port daily there will be need for rigid supervision over the disposal of sewage from these boats. Tramp steamers operated in ocean service are not equipped to comply with the sanitary demands for fresh water navigation where the safety of public water supplies is concerned. As a world port seamen from all parts of the globe will man boats arriving at Chicago. Among them there may be "carriers" of typhoid fever and the dreaded cholera. This pollution of the lake waters in the vicinity of our intake cribs by sewage discharged from these vessels would jeopardize the health of millions.

Protection of the Water Tunnel System

While plans for the construction of filtration plants along the lake front are being developed there is need for a careful study of the water tunnel system which will be used to distribute the filtered water to pumping stations. With approximately 35 miles of tunnels under

the city and over 50 shafts connected to them it is important that the tunnel system be protected against pollution from surface sources. A tunnel shaft in close proximity to a sewer is in a potentially dangerous condition unless the construction of both is such that leakage is impossible. Last year such a condition was found to exist and the water supply was grossly polluted until protective measures were provided. When shafts are of brick construction it is important that they be made impervious to surface seepage. All private connections to water tunnels or shafts should be eliminated and in the future prohibited. Cross connections between abandoned water tunnels and those in service should be effectively sealed. In the case of tunnels passing under private property supervision over deep under ground construction in their vicinity should be rigid.

Cross Connections with Public Water System.

After a pure, wholesome and safe water has been obtained it is essential that it be not contaminated in the mains in delivery to the consumer. In this state, explosive outbreaks of typhoid fever and dysentery in Elgin, Bloomington, Rockford and Greenville, resulting from pollution of the public water supply by contaminated water from private sources through cross connections to the public water system, have given solemn warning of the danger of cross connections. During a survey made by the Health Department in 1924, 191 cross connections to the city water system were found to exist. Sixty-nine (69), or 36.1 per cent were of the direct and dangerous type. Recently inspectors have found that in many large hotels and institutions, where one or more sub-basements are used, waste connections from water filters and condensers are directly connected to the city sewers in such a way that with the flooding of the sewers, sewage could back up into the water system. Conditions of this kind are of great potential danger and should be given special attention. There is need for a revision of the present plumbing ordinances and a substantial increase in the plumbing inspection personnel in the Health Department.

Water Supply for Vacationists

In order to protect citizens of Chicago against water-borne infection, the Health Department must do more than insist on a safe public water supply. It must see that Chicagoans who leave the city for the day, over the week-end, or for an extended period, are warned against drinking unsafe water. Each week-end during the summer hundreds of thousands of our citizens make auto trips to points outside of the city, particularly to the Forest Preserves. There are many convenient but unsafe sources of water in these rural districts. If Chicago is to protect itself against sickness from infection received from these sources it must take offensive action.

During the vacation months thousands of Chicago families, especially the women and children members, go to summer camps in the surrounding country. It is part of the duty of the Health Department in protecting the rest of the citizens to see that these families do not return with members sick from preventable diseases, particularly typhoid fever. If this phase of public health work, which is to a considerable degree sanitary engineering, could be fully developed it is probable that the summer peak in our monthly typhoid fever curve could be considerably flattened.

Bathing Beaches

Chicago's bathing beaches offer another opportunity for real public health service. It is estimated that the attendance at these beaches during an average summer is over 3,000,000. During 1924 a study of the pollution of the waters of 26 bathing beaches along the lake front was made. While in general the condition of the water was reasonably satisfactory, instances of very serious pollution were found. The bathing load in some of the public beaches is exceedingly heavy. It is possible that the chlorination of the waters of these beaches might improve conditions considerably. This matter should be given careful attention. After storms the waters in some of the beaches are seri-

ously polluted, due to river reversals or runoff from the surrounding area. There is need for much more rigid supervision over the sanitary quality of the waters in public bathing beaches in Chicago.

Outdoor Swimming Pools

In many of the large public parks in this city there are outdoor swimming pools which are used during the summer months. In 1924 routine samples of water were collected from 33 of these pools. The results of analyses showed that in spite of the large quantities of water passing through the pools for dilution purposes, the quality of the water was frequently unsatisfactory. Considering the bathing load in these pools it is important that the water used in them be continuously treated for disinfection. In most cases a re-circulating system provided with equipment for filtering and continuous disinfection of the water would not only provide a more satisfactory water for the pools, but probably result in a financial saving over the present method of water wastage.

Indoor Swimming Pools

The increased popularity of indoor swimming pools in Chicago presents still another important health problem. In 1924 a preliminary study was made of 48 swimming pools in public schools, private and public institutions and public natatoria. This showed the need for more careful supervision and control over these places. The most satisfactory results were reported from pools equipped with a re-circulating system used in conjunction with filters and apparatus for continuous disinfection of the water. Periodic treatment of the water for disinfection is usually not satisfactory. In the public schools water wastage in the swimming pools is considered excessive.

In some of the Turkish and Russian bath houses conditions were particularly bad. The water in the plunge and bathing pools was frequently found to be grossly contaminated. This was especially true of the so-called Mikvah or religious pools. The whole proposition of indoor bathing places is an important one from a public health and hygienic standpoint and should be rigidly supervised and controlled.

Mosquito Control

Chicago and its suburbs have a real mosquito problem. In the districts bordering on the Desplaines River is this especially true. Last Fall discomfort from the pestiferous types of mosquitoes was prolonged and acute. Fortunately the danger from malarial fever is remote, due to the absence of "carriers." With a proper organization it should be possible to control mosquito breeding in the vicinity of Chicago.

Rat-proofing

Chicago has ambitions to become a world port. With the completion of the Great Lakes-St. Lawrence River waterways it will be. When this day comes new health situations will have to be faced. It is now not too early to lay the ground work for this project. Not the least of these will be the protection of the city against possible plague infected rats from foreign ships. At the present time the rat population in this city is excessive. Favorable rodent housing conditions exist in practically all parts of the city, particularly in the areas most affected by lake shipping. Should the rodent population become infested with plague infected fleas the cost of rat-proofing as a plague preventive and control measure would be enormous, judging from the cost for similar work in New Orleans, San Francisco and Los Angeles. To determine the rodent population in various sections of this city, to identify the species of flea living on these rats, to make preliminary estimates of the cost of rat-proofing and to prepare for better rat-proofing construction, a systematic rodent survey should be conducted. This work properly devolves on the engineering personnel of the Department of Health.

Housing

It is becoming increasingly evident to public health students that environment is no small factor in influencing health conditions in a community. A proper proportion of air, sunlight and freedom

from contact with other individuals cannot be obtained where congested housing conditions exist. Housing problems are fundamentally engineering and properly belong to the public health engineering group. In Chicago there is an acute demand for a thorough and systematic study of housing conditions, particularly in connection with the enforcement of building laws and the proper development of the zoning program.

Air Conditioning

The health significance of air pollution is becoming more and more apparent as scientific studies of respiratory diseases are being made. With common colds, pneumonia and allied diseases ranking all other monthly statistics, public health research workers are naturally directing their attention to studies of the degree to which atmospheric conditions affect the spread and transmission of these diseases. Fundamentally the problem of air pollution is that of preventing gross pollution of the outside air in closely built up districts.

The acute need for smoke abatement in Chicago is obvious to all of us who work in the "Loop" district. The pollution of the air by dangerous gases, such as carbon monoxide, emitted from automobile exhausts, sulphur dioxide from stacks, and poisonous fumes from industrial plants are very important matters of health and civic concern. The providing of proper air conditions inside of buildings housing large numbers of people, is receiving the careful attention of ventilating engineers. It is well known that there is a relation between proper ventilation and health. To solve the economic and health problems involved the health officer and ventilating engineer must work in harmony. There are great opportunities for study and intensive work along these lines.

Industrial Sanitation

Chicago is a fertile field for industrial sanitation work. The influence of conditions in industrial plants on the health of a community has been realized for many years, but unfortunately owing to the economic problem concerned, this public health function has not received the attention it deserves. With the exception of the more dangerous industries relatively little has been done by health officers in improving the general conditions under which the workers live. Considering the hours spent in places of employment, and the influence which sanitary conditions in these places must have on the general condition of one's health, it is obvious that there is a field for real health work in industry. To no small degree this problem is an engineering one and must be worked out as such.

It is hoped that the foregoing brief discussion of the public health engineering problems which must be solved for the welfare of Chicago and its citizens will serve to emphasize the fact that among the many activities of the Health Department of this city there is much for engineering services of a high order. The newly created Bureau of Sanitary Engineering in this Department is the logical standard bearer for this work and deserves the fullest support of engineering organizations.

Zoning and Housing

By CHARLES B. BALL*

Presented February 19, 1925

The past decade has witnessed the introduction of zoning principles in the planning of American cities. The advantages are here set forth in a general way. Better design of street systems and utilities may be secured.—Editor.

ZONING ordinances are now in operation in more than 300 cities of the United States, and are constantly being applied to other cities and towns. The general purpose of zone regulations is to divide a city into districts set aside, respectively for residence, business and industrial uses, to the end that the health, comfort and general welfare of the people may be promoted by the segregation of each such use apart from the others. Of course, in applying such a system of regulation to a city which has grown in a haphazard way, careful study must be made of existing conditions in order that the boundaries of the various districts or zones may be properly developed.

The principal advantage in the parts of the city set aside for dwellings is that factories and stores are excluded from them, and for that reason such neighborhoods become more suitable for home development.

Before considering the advantages, let us discuss the effect of zoning upon the design of the street system for home neighborhoods.

Land Sub-Division and Housing

In most cities, the sub-division of land consists in laying out blocks and streets with little attention to their ultimate use. Slight discrimination is shown in providing streets for residence or business or industrial uses. The length of blocks, which may be greater for industrial areas than for residence and business is given no consideration. Only when zoning is introduced as a factor governing street design is it realized than in the laying out of residence streets, directness is unnecessary, and curved, narrow streets are desirable, both because of their beauty and because they discourage the use of such streets for thoroughfare purposes. Indeed, the street plan to supply local needs should provide streets which are not adapted to serve the purpose of main highways, and discourage through traffic. Street paving also, regulated by pre-determination of the use to which the streets are to be subjected, need not be heavy and the roadways need not be wide in neighborhoods in which dwellings are to be built. These considerations produce cozy, attractive home neighborhoods which have a distinctive domestic quality and stimulate civic pride.

A recent authority has said;

"Probably the most prolific fundamental cause of bad housing, as well as of other evils, is the widespread method of subdividing land into streets and lots of more or less uniform or standardized sizes regardless of topographic conditions, position in the city structure, and probable use."

(Proceedings Am. Soc. C. E. February 1925, p. 174:)

Zoning Prescribes Space About Houses

In unzoned cities, even in the few which have housing laws, the open spaces left on the lot for light and air at the rear of dwellings, may be quite inadequate (Philadelphia, 144 sq. ft.) and the cramped courts between houses notoriously so. Few of the windows which open at the side of a house (about 50% of all windows) are comparable in their capacity to afford light and air to those which open at the front of the house.

Zoning equalizes window opportunity by the application of the principle of graded building regulations, which require larger back yards, wider courts and side yards, where land is cheap.

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than in built-up neighborhoods where land is dear. Some ordinances prescribe, in highly restricted districts, a definite distance (5 or 6 ft.) between the side lot line and any wall which contains a window.

Zoning also increases the open space about dwellings by prescribing in percentage terms the amount of the lot which a building may cover. It is common in open districts to provide that at least 50% should be left vacant. The main purpose of such a provision is to insure that spaces now left open when a house is built shall not be subject to occupation after a time, when the land is more valuable by reason of increased intensity of use.

Another way in which zoning provides for open spaces about all types of dwellings is by regulation of the area of the lot with relation to the number of families that may be housed upon it, or the same thing expressed in another form, by a limitation of the number of families per acre of ground.

These standards must be fixed to harmonize with the prevailing types of houses and lot sizes in any community. If an ordinary lot size is 40x120, it is appropriate in a one-family district to prescribe not less than 4800 sq. ft. per family; in a two-family district not less than 2400 sq. ft., and so on down to 600 or 400 sq. ft. for a high value district, in which large high-class apartments would be appropriate. This type of regulation forestalls the tendency to create more and more intensive housing until slum conditions result.

Height Affects Housing

A primary principle of zoning is the regulation of height of new buildings which bears a well-defined relation to the use requirements of zoning.

In any city which has grown for a considerable period without zoning requirements may be found glaring examples of small buildings, usually dwellings, shut in by an adjoining tall brick wall of factory or warehouse. Such eclipsed buildings are deprived of their due proportion of light and air, and may be avoided in the future by the application of adequate proportional zoning requirements.

While high office buildings, warehouses and in some cases factories will persist for many years, it is recognized as reasonable that in residence districts a relatively low maximum limit should be imposed which new buildings may not exceed.

The height limit, often fixed at, in single family districts, 35 or 40 feet results in a fairly uniform development of the roof line, broken occasionally by towers and gables, but in the end tending greatly to facilitate access of sunlight and circulation of air.

Zoning Restricts Industrial Nuisances to Factory Districts

A primary purpose and effect of zoning is to restrict industries which usually produce nuisances to allotted districts, instead of allowing factories to mingle with dwellings in business and residence territory. This is a marked advantage for the factories as it allows them to operate without undue restriction and is of still greater advantage to the home neighborhoods from which they are excluded.

To render the homes of the people free from noise, smoke, fumes, odors and dust promotes the comfort and health of the people. More and more attention is being paid to the purity of the atmosphere in the prevention of disease. While smoke may not be necessarily incident to industry, it is a very common accompaniment at the present time. Odors and fumes prevalent in factory neighborhoods and to some extent unavoidable to certain industries as in the production of chemicals, constitute pronounced nuisances in residence areas. The effect of odors is not uniform on different people, and in some cases certain odors produce marked discomfort and disturbances of the digestive functions.

The disadvantage of dust in the air is coming to be well recognized. Its presence tends to irritate and clog the lungs and air passages and it may even cause marked wounding of the mem-

branes of the mouth and nose, so that bacterial infection is liable to follow. Dust injures the eyes and clogs the pores of the skin. Young children are especially subject to annoyance from these effects.

The discomfort and damage due to noises in the home are more and more coming to realization. The common impression that many noises are incident to life in a great city is by no means well founded. The effect of noises in preventing restful sleep has become a subject of scientific proof by which it is shown that although a fatigued person may fall asleep where noise prevails, such sleep fails largely to produce restful effects.

In any residence community, there are about 2% of sick people who are constantly subject to discomfort by reason of noise.

The required sleep of babies and children under five is subject to much disturbance by noise. Even street noises prevent adequate rest for the child. In addition to this, there is a considerable number of night workers in any residence area who require quiet for daytime sleep. The limitation of noises to commercial and industrial districts by zoning is of great advantage to the territory in which homes prevail.

Since zoning ordinances are not retroactive, they have little or no effect in removing existing minor nuisances from districts of congested housing. Examples of such nuisances, non-conformable to the use limitations provided, are untimely noises, such as result from handling milk cans in the early morning hours; hammering and pounding, such as take place in boiler factories and auto repair shops; odors, such as constant gasoline fumes from testing internal combustion motors; dust, from cleaning carpets or the unloading of coal in the open; and the presence of flies attracted to stores and markets.

Zoning laws would doubtless prevent the intrusion of nuisance-producing industries into existing and newly occupied residence districts, and after a number of years will afford some relief in localities where noise nuisances now produce discomfort.

Zoning Vegetation

Adequate zoning offers, even prescribes, larger areas devoted to grass and trees in residence districts than are required in districts for other types of use. The advantages derived from grassed yards, cultivated gardens and other vegetation are much more than an improved aspect of the buildings and their surroundings. The shade from trees is grateful in summer, and in winter they do not obstruct sunlight as do brick walls. Trees, shrubs and grass automatically regulate heat conditions. Vegetation also is necessary to maintain the chemical balance between oxygen inhaled by human beings and all animals and the carbonic acid required for the plants which in growing give out oxygen.

Stability Produced by Zoning

In the popular mind the greatest advantage which results from zoning is the permanence of a given use, especially the use for dwellings in a given neighborhood. This advantage to the home owner and to the districts in which multiple dwellings prevail is marked and especially to the householder who owns only a humble dwelling.

The changes which come in cities so as to affect the value of the homes of the well-to-do are especially damaging to the worker who has little investment other than his home. If one builds a mansion which lessens in value by proximity of industry or business, his resources usually allow removal to some other district. If on the contrary, a residence district of humble homes depreciates in value, due to unfavorable intrusions, the owners of such homes have little recourse but must endure the depression or lose their homes.

Chicago Unzoned

Let us consider what would happen in the next generation if the present haphazard distribution of industry, business and residential development be continued. The difficulty now experienced

of locating industries in suitable situations would be enhanced a hundredfold. No protection would be afforded any part of the city against nuisances caused by objectionable plants. Stores of all kinds, great and small, would invade residential areas. The loss of values which would ensue for every type of use can hardly be imagined. Neighborhoods in which quiet now prevails would become impossible to live in. Properties purchased for one use would be given up at a sacrifice for a different use. No stability could be prophesied for any real estate investment within the city limits. Turmoil, dissatisfaction, unrest and dislocation would become predominating factors in our city's growth.

Chicago Zoned

Contrast with this what will happen under adequate and comprehensive zoning. Like a well regulated business, the city would shortly present evidence of the application of a well conceived plan of development in which every part of its area would be devoted to a suitable use and denied to inappropriate uses. Industries on which the life of the city depends would be classified into such as are objectionable and those which cause no nuisance. Nuisance plants would be set apart by themselves in regions far removed from the homes of the people. Those industries which may be placed adjacent to residential areas would be provided with suitable opportunities for expansion. Business establishments would multiply along the thoroughfares with consequent rising values of such properties and resulting convenience to the distributor, merchant and purchaser. Above all, the dwellings of the people, rich and poor alike, would possess those attributes which are necessary for healthy home life. Light, air, quiet, freedom from intrusion of inappropriate elements.

As an observer of German cities, who closely noted the effects of zoning in those cities, it would be true of Chicago when zoned that "There has been *evolution* guided by *purpose*—a *purpose* to create diversity out of which would emerge *unity* and *completeness*."

Public Safety

By SIDNEY J. WILLIAMS*, M. W. S. E.
Presented February 19, 1925

Industry, formerly the great offender in causing accidental fatalities now causes only one-ninth. Safety methods are largely responsible for this reduction. Can they do as much on our streets where our accident problem now exists? The author of this paper thinks they can, and backs up his convictions with some interesting facts.—Editor.

NEARLY 2,000 persons are killed annually by accidents in Cook County; about one hundred times as many are injured and some of them permanently disabled. The direct economic cost of these accidents is conservatively estimated at $50,000,000, including loss of time and earning capacity, medical and hospital expense, and property damage, but not including indirect costs such as the delay of industrial operations and of street traffic. About three-fourths of these accidents occur in the city of Chicago.

If "self-preservation is the first law of nature", why do we have this accident problem and why do we need an organized safety effort to meet it? If we were still exposed only to stone age perils such as falling out of trees or stepping on snakes, the accident death rate would be a sizable one but nothing like what it is, because our slowly developed instincts warn us against such hazards. But the processes of evolution have been accelerated a thousand fold by our modern industrial civilization, which is creating over night wonderful new instruments for our business and pleasure, and many of these have

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brought with them their own new dangers against which our self preservative instinct is no safeguard. Or rather, the self preservative instinct today takes the new form of an organized safety movement which is struggling valiantly to keep pace with, and even to overtake, the organized creation of the new hazards of our electrical, chemical, and mechanical development.

Accidents On Streets

In Chicago and Cook County the accident problem today is on the streets rather than in the industries. Traffic, including railroads, elevated and street cars, and motor vehicles, is now responsible for more than half of our accidental fatalities while industry causes only one-ninth. The remainder are from asphyxiation, burns, drowning, falls, etc., in the homes and in miscellaneous public places. Motor vehicles are involved in more than one-third of the total. The automobile today is easily the greatest single factor in accident causation, in Chicago and elsewhere. This is no indictment of the automobile as such, nor would any of us wish to return to the horse age, but the death of more than 20,000 of our countrymen in automobile accidents in 1924 makes it perfectly clear that the mechanical development of this wonderful modern necessity has far outstripped our ability to use it in safety and comfort. Our manifest failure in this respect, which has made automobile accidents a pressing national problem, has occurred along at least three important lines:

1. In the physical capacity of our streets and highways.
2. In our traffic laws and their enforcement and
3. In our personal self control in driving these scores of mechanical horses that respond so readily to our slightest touch.

Where, how and why do these automobile fatalities occur? In Chicago in 1924, four-fifths of all the persons killed in automobile accidents were pedestrians; the remaining one-fifth covers collisions between motor vehicles, collisions of an automobile with a railroad train, street car, or fixed object, overturning, and miscellaneous. Whoever may be most at fault, it is clear that the pedestrian is the greatest sufferer.

Of the 441 pedestrian fatalities in Chicago in 1924, 90 occurred on the boulevards and through streets and 351 on other streets. On every ten miles of through streets there were, on the average, not quite six pedestrian deaths; on every ten miles of other streets, one and one-half pedestrian deaths. Considering the much greater volume of traffic on the through streets, this record indicates that our boulevard and through street system not only helps to move traffic but helps to keep down accidents, when traffic at intersections is controlled by signal lights and officers and when speeding is checked by the constant activities of the police.

Both these items—traffic control and speed—deserve further attention.

Control Speed

It is clearly established that proper control at intersections not only keeps the traffic untangled but keeps down accidents. The installation of the present automatic signals on Michigan Avenue was followed by a decided drop in fatalities. The National Safety Council has recently completed a survey of Cleveland which showed a much higher fatality rate on the arterial highway system than in Chicago and we believe that this was due chiefly to less extensive traffic control and to greater speeding. For a city to set up a system of through streets having legal right of way and then provide no effective check on speed and no safe way for pedestrians to cross at intersections, is simply to invite reckless driving and wholesale slaughter. I am happy to add that the present police authorities in Cleveland are now introducing more effective control measures which have already shown a reduction in the accident rate. And while speaking of control at intersections let us put in a plea for some change in our Chicago whistle signals, to give the pedestrian a fair chance to get across the street when the traffic changes!

If Chicago's record of 109 automobile fatalities in a single year, on the boule-

vard and through street system alone, including 90 pedestrians, is lower than it might have been, it still is nothing to be proud of! No man in his senses can deny that these fatalities can and must be much further reduced by extension of traffic control, educational measures, and suppression of speeding.

Now consider the element of speed. I have been amazed to read reecently in an engineering magazine, the statement that speed is not a cause of accident. It is certainly true that speed is not the sole cause of vehicular accidents; that many accidents happen at low speed; that ten miles per hour through a Christmas crowd in the loop may be more hazardous than 40 on the open highway, and so on. But so long as the energy of a moving object varies as the square of its velocity, and so long as the stopping distance of a moving object under constant deceleration varies in the same ratio, who can deny that *under given conditions*, the greater the speed the greater the likelihood of accident in any emergency? Two cars approach a blind intersection; regardless of legal right of way, at 15 miles per hour one or both of the cars can stop or swerve and avoid a collision; at 30 miles they can't. A child runs into the street from behind a parked car. He has no legal right there—but who wants to kill a child? At 15 or 20 miles per hour we can avoid him—at 30 we can't. Any emergency in crowded traffic—hitting a stone or a rut, blowing a tire, a miscalculation of distance—is hazardous in proportion to the speed or to the square of the speed. This will remain true as long as the laws of motion, which have not yet been successfully amended by any legislature nor by any man or body of men whose God is Speed.

This general statement should be capable of proof by experiment, and it is. On July 8, 1924, after considerable newspaper publicity, the Chicago Police Department began rigorously to enforce a 20-mile speed limit. In the 30 days preceding there were 60 automobile deaths on the streets of Chicago; in the 30 days following, 28. After the first month, lawyers and judges began questioning the exact intent and meaning of the speed law, which I shall not stop to discuss—and the police drive largely lost its force. But the lesson of those 30 days cannot be denied.

Most Efficient Speed

If speed were necessary to move the traffic in a modern city, the question might fairly be asked—Is not some sacrifice of life necessary for the greater good of the city's life as a whole? But this is not the case. Traffic engineers and city planners have developed formulas and curves showing the number of vehicles passing a given point at various speeds. The curve developed by Olmsted, Bartholomew and Cheney on one basis of data and assumptions shows that the maximum number of vehicles will pass a point at about 23 miles per hour; that this number is only four per cent greater than at 17 miles; that for speeds over 23 the number actually decreases. On another set of assumptions the greatest number will pass at a speed even less than 15 miles per hour. Obviously the way to move traffic is not through the reckless speeding of individual vehicles but by maintaining a high *average* speed of all vehicles and by using the entire street width for moving traffic and not for parking.

Returning to our statistics—351 pedestrians and 97 others were killed on the Chicago streets in 1924, in motor vehicle accidents outside of the boulevard and through street system. Fifty eight per cent of these were at intersections and 42 per cent were not at intersections. As the number of pedestrians crossing the street or in the street at intersections is obviously very much greater than between intersections, it is evident that the accident frequency between intersections is much higher. Nearly two-thirds of these "between intersection" accidents were children running into or playing in the street; most of the remainder were adults crossing the street. Is it necessary to say that the "jay walker" and the child playing in the street are taking chances? But what are the remedies? As for the children, we can't stop them from playing, if we wanted to. The modern city does many

evil things to the tenement-house child—whether the tenement is on Halsted or in Hyde Park—but at least we can give him a safe place to play. This runs into city planning, zoning and playgrounds, and all I need say is that every consideration of safety adds further weight to what we know needs to be done along these lines. May I add this—don't put your playgrounds on a heavy traffic street or where the children will have to cross such a street to reach it! This, absurd as it may seem, has been done all too often.

Teach Safety Principles

One of the obvious remedies for these child accidents is greater carefulness by the children. Safety instruction in the schools is now accepted by educational authorities as well as by safety organizations; the National Safety Council and its local councils are spending well over $100,000 annually in the promotion of such instruction, which not only helps to save the child from immediate harm but makes him in every way a better citizen when he grows up. This is too long a story to tell here. But let me add that the motorist also has his responsibility. Speed is a big element, as I have already pointed out. So long as our children have to play in the street, I maintain that it is the obligation of every one of us, and of every driver, to keep his vehicle under such control that he can avoid striking a child at play. No business organization has any right to demand of its drivers in crowded residence districts a daily mileage inconsistent with this rule of safety.

One of the things we most need, for prevention of reckless and incompetent driving, is a driver's license law such as those now in force in New York, Massachusetts, Connecticut, Pennsylvania, Maryland and elsewhere. I recently completed a careful analysis of state automobile fatality records which indicated strongly that such laws, where properly enforced, have helped to stop accidents. Such a law should provide for a competent state bureau to license all drivers; those now driving to be licensed without examination except where serious physical or mental defect is evident; new drivers hereafter to be examined as to competency; any license to be revoked or suspended by the state department for reckless or unsafe driving.

I have touched on only a few of the high spots in this great and intricate problem. There are many other contributing causes of accident — ignorance and inattention on the part of both motorists and pedestrians, and many minor causes—for which the principal remedy must be a continuous organized campaign of public education, using standardized methods which I have no time to outline in detail. There are however three points which I cannot avoid mentioning.

In our recent check up of the Chicago experience to obtain the figures which I have quoted, we found it necessary to make a map of the boulevard and through street system of Chicago and I was amazed to see how unsystematic this "system" is. It seems to be a fact that through streets have been established according to local demand and not according to any well considered general plan. Does not our Chicago plan include a comprehensive present and future system of principal thoroughfares? Are not these the streets to which, and to them alone, the through street ordinance should be applied? In other words, should we not first determine what streets are or should be thoroughfares, and then make these real thoroughfares through improvement of paving, widening where necessary, and legal right of way for traffic thereon?

Relieve Grade Crossings

My next point is with regard to railroad grade crossings and accidents thereon. Many of the crossing grades in Chicago have already been separated and the total fatalities at crossings in this city are a rather small fraction of all traffic fatalities—yet the recent catastrophy on North Avenue reminds us that this problem is not yet solved. It is customary to point out the great cost of grade separation, and this element must not be overlooked. These crossings cannot be wiped out by a stroke of the pen or by a resolution of this

Society. The handling of side tracks is an additional complication. But there is another side to the question—there are assets as well as liabilities to be considered. If the average cost of eliminating a grade crossing is $100,000, and if one person per year were killed at every such crossing, and if the average value of a human life is $5000 or $6000, then obviously the saving in this direct accident cost alone would pay interest charges on the investment. Actually the accident toll is not as great as this. But there are other items. Proper watchman service at a grade crossing means an annual expenditure running into the thousands. The maintainance of crossings, especially crossings of street car lines, is expensive. And, perhaps greatest of all, consider the cost of holding up all street traffic for the passage of passenger and freight trains and, worse yet, for switching operations. For any given crossing or any given railroad line it would not be difficult to figure an approximate balance sheet of costs versus savings, for both the railroad company and the city and I am confident that any such accounting would show economic justification for eventually eliminating practically every grade crossing within our city limits. Pending separation, surely the best possible protection should be provided. There is a trial installation at a railroad crossing in Syracuse, of an ordinary street-intersection signal light. There are six railroad tracks, three for through trains and three for switching. When the light shows green to the train crew it shows red to the motorist and vice versa. The light is controlled by the towerman. This looks like a big improvement over the usual waving of lanterns.

My remaining point is on the height of buildings. This relates to safety in two ways. With the best of protection, high buildings involve a very serious life hazard from fire as well as a serious health hazard, as was clearly brought out in the Chicago Real Estate Board hearings on the zoning ordinance. And high buildings increase congestion which increases traffic accidents. City planners have given up trying to design streets to care for a square mile of even twenty story buildings. It can't be done. The remedy is decentralization and this means not simply the prohibition of excessive building heights but, on the positive side, the wise planning of sub-centers, satellite cities or suburbs, each self-contained as far as possible and each planned to avoid in itself the evils of congestion. Here again, the element of safety simply adds weight to other city-planning considerations. If we plan wisely, we shall plan safely.

Super-power and Its Social Significance

By R. F. Schuchardt*, M. W. S. E.

Presented February 19, 1925

Chicago has reaped the benefits of super-power without realizing it as its power system is a practical demonstration of the principles here set forth. The city is now the center of a large power network which is ever increasing, with a resultant saving in fuel and energy and relief of congestion in over-crowded industries.—Editor.

SUPER-POWER is a term which is much in the public print. There are various conceptions of it, most of them more or less vague. These range all the way from a beneficent servant possessing the power of magic and ready to do our every bidding to a diabolical monster with outstretched claw anxious to grab unto itself all the wealth of the nation. Of course, no person with a healthy mind has the latter conception. Leaving out the magic, the first named conception is not far from fact. But super-power is no wonderful creation of the hour. It has been with us for decades and is but the

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natural development of the electric power industry.

We can understand this industry and its relation to society best by viewing it in its historic perspective. This takes us back almost to the beginning of things when the human muscle was the only power under the control of man. The steps in man's progress toward a better and fuller existence are marked by improvements in the means for producing necessities. We shall skip hastily over the long centuries when the average man's lot was heavy toil and drudgery, and hesitate for a moment at that wonderful 15th century. That period was marked by the invention of the printing press, by the work of the great and versatile da Vinci, by the discoveries of Columbus, and the early days of Copernicus, whose later work changed men's thinking,—all of which gave a tremendous impetus to civilization. It expanded men's minds, but did not relieve them from physical drudgery. That remained for the 19th century when the steam engine literally saved civilization after the exhausting Napoleonic wars. The work of the brilliant James Watt and succeeding engineers bore fruit and civilization was completely transformed in a few short decades. Culture and the enjoyment of comforts, hitherto the possession of the few, now became available to the many—and all because of the great increase and comparatively low cost of mechanical power.

The use of steam was limited to the location of its production. Its range is the length of belting and line shafting. After a reign of a short half century there came a new power, the perfect servant, electricity, made commercially practicable by Edison and others.

Central Plants in Cities

The first central stations for supplying electricity were started in cities forty and more years ago. Then with the passing years they extended beyond the cities and into the surrounding areas. Engineering developments brought about many improvements in producing electricity. Thus twenty years ago it required from 7 to 12 pounds of coal burned in our boilers to produce one kilowatt-hour of electricity, and previous to that as much as 30 and more pounds was required in some plants. Today in our best plants less than two pounds of coal is burned for each kilowatt-hour generated. What this improvement means to the nation in the hundreds of millions of tons of coal saved to date can be readily appreciated. Had the efficiency of production remained unchanged in the last twenty years the coal burned by the Chicago system alone in 1924, assuming that the output would then have been what it actually was, would have amounted to about 10 million tons instead of 3 million. Or, taking the shorter period of the last 5 years, for the entire country, the electrical industry by its advances in electricity production has saved the nation 30 millions of tons or more than the total coal mined last year in either Indiana or Ohio and nearly one-half of that mined in Illinois.

The conditions of use and the distribution problems also were constantly studied for the purpose of improvement. This resulted in many operating economies which were reflected in lowering cost of the service. The natural result was a great expansion of the industry, making possible the building of large and highly economical plants and a further reduction in the cost of the service to the public. Thus the last ten years has seen a decrease of nearly 9% in the average cost of electric service in the United States in the face of a weighted average increase in cost of living of over 70% according to data of the United States Department of Labor.

Advances Civilization

The possession of this cheap and clean power has speeded industry and brought the benefits of health, comfort and conveniences to every man's door wherever the distribution lines carry the energy. There is no need to enumerate for this audience the many ways in which electricity relieves us of burdens and adds to our comfort. Think of what you would be deprived if there were no electricity at your command. By giving man more leisure for cultural develop-

ment electricity has probably been the largest single element in his upward movement to a fuller life. Bringing this opportunity to an ever increasing number moves civilization forward apace.

The rapid extension of our electric systems with their networks of distribution lines is bringing these benefits to a larger and larger number. Interconnections are continuing to be made between adjoining systems, large and highly efficient power stations are being built at most economical locations, water powers that can economically serve the nation are being woven into the picture, and industries having waste heat before long will be in the scheme—all as the natural development of the electric service industry—and we now call this super-power.

Super-power results in the saving of two very important of the nation's resources—fuel and money. The fuel saving has already been referred to. The money saving results from the fact that with interconnections and large stations less investment is required for a given area and the dollars invested work more industriously. This, of course, does not mean that interconnections are or should be made promiscuously. They will not and should not be made unless justified by the conditions in each particular case.

Utilizes Waterpower

There is unfortunately not time to go deeply into the question of water power development regarding which there is much misunderstanding. Super-power makes it economically practicable to use water power to a much greater degree than was the case in the past. It should be noted, however, that there are many rivers that can never be extensively developed for power. Some have a very heavy flow amounting to flood, for a very short period, during which their course is some times changed, and then little water during the rest of the year. The large investment necessary for dam, power house, dikes, flooded land, transmission lines, substations, etc., would in such cases be idle or nearly so the greater part of the year, while the interest charges on the money used, the insurance and depreciation costs and the maintenance expense run on continuously. The problem is not a simple one, but certain it is that if the power development of any river can be made so as to result in cheaper power, or without increased cost to save fuel, then the electric power industry will make it. There are countless evidences of this in the water power regions of the country. About 35% of the electricity produced in central station systems in the United States today comes from water powers.

Water Supply Determines Location

There are some who think that society would be benefited if our power stations were all located at the mouth of mines; yet it is only in rare instances that this would result in a lower cost of bringing electric service to the public. In order that steam turbines may operate efficiently, that is, with the least amount of coal burned per unit of output, it is necessary to condense the steam after it has passed through the turbine. This requires vast quantities of cool water to flow through the condensers. The actual amount of cooling water depends on its temperature and on the design of the plant, but it varies from about 500 to 700 tons for every ton of coal burned under the boilers. The plants in Chicago, for instance, pump through their condensers an average of about 900,000,000 gallons of water per day, an amount larger by 100,000,000 gallons than the very large quantity passing through the city's pumping stations. Smaller stations naturally need correspondingly less cooling water, but there are not very many sites at coal mines where the required abundance of water is found. A number of such sites do exist and most of them now contain power houses.

In connection with these questions of power house location and water power development it should be noted that the electricity production or station operating cost is usually but a comparatively small part of the average cost of elec-

tric service delivered to customers. As a rough measure of this may be cited the fact that in the case of an electricity supply company having a high record for efficiency less than one-seventh of the employes are engaged directly in the operation of the generating stations. The kilowatt-hour at the generating station is somewhat analogous to coal loaded on mine cars. Its cost in the car at the bottom of the mine is far less than its cost delivered in the user's bin. It must be hoisted to the tipple, dumped, screened and loaded on cars, hauled to distant yards, unloaded and again loaded on wagons or trucks, carried to the customers and finally delivered in the bins. The very large user who takes his coal directly from the cars on a railroad siding obtains a commodity that has required a lesser investment and a lesser cost of handling than has that delivered in the domestic bin. The parallel is obvious.

In the foregoing the direct economic gain to society from super-power was pointed out, and the possibilities of cultural gain were touched on. Electricity has truly been called "the greatest accelerator of production and the most helpful burden bearer introduced by engineers to modern civilization."

Chicago Leads in Power Prodution

How widely has this burden bearer been introduced? Central station electricity produced in this country was about 550 kw.-hr. per capita last year, while in Switzerland with its many water powers and small population (4 millions) the many electrified railroads bring the corresponding figure up to one at least half again as large. But in England, which has so many municipal plants, the production is less than one-third of ours. The Chicago production of 950 kw.-hr. per capita last year is nearly five times that of London. The development of the Chicago system has made this region one of the very important centers of super-power. The combined capacity of the stations in the power pool in this northeastern corner of Illinois will this year exceed 1,000,000 kilowatts and interconnected lines extend throughout northern and central Illinois and into northern Indiana and will before long link with lines in the areas beyond. Studies of probable growth indicate that within two or three decades the use of electricity per capita in this region will have nearly trebled. Whatever the future may hold for the Chicago region the power supply plans are on a basis of being ready for any probable development.

The amount of mechanical power available per worker is another measure of the industrial standing of a country, as it directly affects the producing ability of the worker. America has about twice the horsepower of machinery per worker of England and four times that of Japan. It is not an accident that the average wage scales in these countries are approximately in the same proportion. The contribution of super-power to the improvement in standard of living is evident. That interesting social student and writer, Robert Bruere, said that the measure of a successful civilization is not primarily accumulated material wealth, but human well being. Super-power has brought both measurably nearer to the average man. Industrially it is coming to do the work more and more of the common laborer, thus tending to offset the handicap of the decreasing supply of such labor, and it is providing the skilled laborer with the tools for greater production.

To carry super-power to that part of our population that has thus far had the least relief from drudgery, namely, the farmer, is the great desire of the industry. To this end it has initiated the organization of joint committees of agriculturists, manufacturers, agricultural college staffs, and electrical engineers to give intensive study to the problem so that the economic questions may be speedily solved. Already many trial lines have been erected and numerous experiments are being made. Some of the things for which electricity is being applied are hoisting of hay, feed grinding, grain and hay drying, pumping for draining and water supply, cooking, baking, laundering, milking, chicken breeding, harvesting, sawing wood, dairying and many others. This will trans-

form life on the farm, making it in many respects more desirable than urban life, and will check the flood of ruralists to our congested cities.

Transmission lines to rural communities and to small cities already are drawing industries away from the overcrowded centers and the shop operatives are finding in these communities far better conditions surrounding them and their families. They are getting back the inspiring contact with nature which was denied them in the crowded streets and in the apartment life of the cities. The important social effect of this can hardly be overestimated. The labor supply there may not be as plentiful, but it will be much more stable, and manufacturers will be impelled to organize their work so as to get the highest annual load factor in order to obtain permanency of their employes. The attendant benefits of this also mark a distinct social gain.

The decreasing supply of common labor in the North has resulted in a large influx of negro labor from the South. As a super-power systems spread in those regions of the South that it has not heretofore reached this migration will be checked. The importance of having the power of Muscle Shoals used in conjunction with the southern super-power systems is clear. It was not climate alone that made New England prosperous nor that is making Illinois today take a place near the head of the procession of economically important states with, in the main, a contented population.

When an industry has such a vital bearing on society and on the body politic as has been outlined above its proper control in the interests of the public served is of paramount importance. Also the orderly progress of the industry, so it may always adequately serve the growing needs of the country, is of great concern to the public. Those who direct these great systems are human like their fellows in other industries and subject to the strengths and frailties of ordinary men. As the industry serves best as a monopoly it is, therefore, both proper and advisable that the public interests be safeguarded by intelligent public regulation. The development, however, should follow natural economic law with human service as the great goal. On any other basis prosperity will forsake it, because as George E. Roberts clearly states in his "Economics," "only those things can endure permanently that aid and benefit the great body of the people."

The great combined systems covering large areas and bringing ultimately to every corner of it the blessings of this burden bearer are viewed with fear by some of the unthinking, and government is urged by them to break up the systems. No significance apparently is attached to the present efforts of government to force combinations of existing super-railroad systems. There should be a lesson in this.

But who owns these great power systems? The wonderful success of customer ownership and employe ownership campaigns has brought a new body of owners into the field so that today, by direct stock ownership and through the investments of insurance companies, these properties are the possession of many millions of us plain citizens. There is no longer any distinction between the workers and the owners in super-power. Truly the work of today with its constant search for economies of which the public reaps the benefit, and with the ever widening range of electric service—this today's work gives assurance that those who are directing super-power are applying a social vision and have a full appreciation of the fact that "he profits most who serves best."

Vehicular Traffic In Chicago and Cook County

By Maj. Geo. A. Quinlan,* M. W. S. E.

Presented February 20, 1925

No Chicago motorist can doubt the need for a better co-ordinated highway system in Cook County if he attempts to travel much outside the city limits. A systematic study of the traffic and its requirements has just been completed for use as a basis upon which to design an effecient highway system. This paper brings out some of the important needs as disclosed by that survey.—Editor.

THE RAPID increase in highway traffic created by the business and social intercourse of the large population in Chicago and vicinity is placing an extremely heavy burden on the highways of Cook County. At the time the Federal Aid law was passed in 1916, it was estimated that it cost more on the average to transport agricultural products from the farms to the shipping point than all the rest of the way to New York and even to Liverpool. With the advent of the improved road that condition was changed, the cost of the local transportation has decreased to a marked degree. In Cook County such charges are beginning to rise again due to the delays encountered by the users of the highways. These costs which might be called the terminal charges are very difficult to estimate. However if all the factors which enter into such an estimate, such as loss of time, spoilage of perishables or expense of so preparing perishables as to prevent spoilage and increased gasoline consumption, are taken into account, the total is certainly large enough to deserve the earnest consideration of all public officials charged with highway construction in terminal areas.

The Chicago terminal area might be considered as all that territory lying within a radius of fifty miles of the loop district of Chicago. Such area extends from the Wisconsin-Illinois

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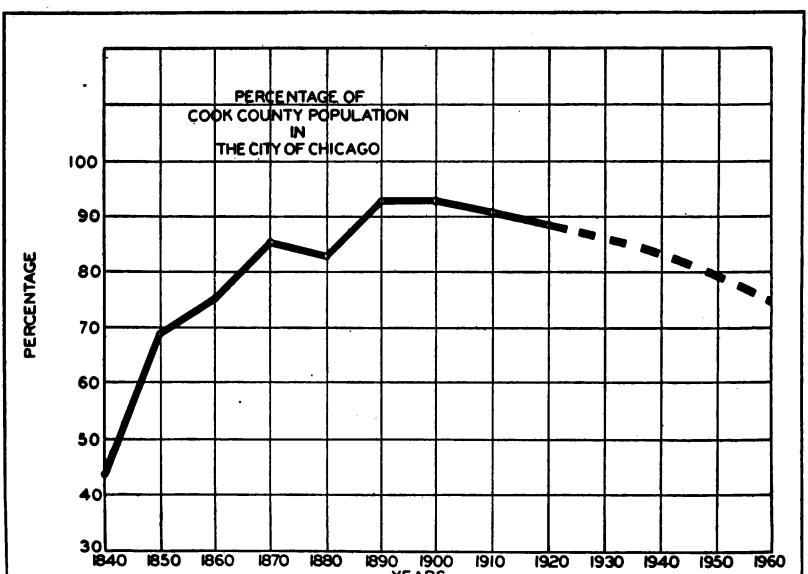


FIG. 1. CHICAGO'S SHARE OF THE TOTAL POPULATION OF COOK COUNTY IS DECREASING.

State line on the north to the Michigan-Indiana line on the east. It includes all of 6 counties and portions of 6 others. Within this area are 167 cities and villages and the combined urban and rural population is nearly 4,000,000.

To study this entire problem in Cook County, a traffic survey was made during the summer and fall just past. I regret that the tabulation of the mass of data obtained has not been completed, and so no recommendations can be made. However, I can give an outline of our problem and the methods we are taking to reach a solution which will be based on a comprehensive and scientific study of present conditions and an estimate of future growth.

Chicago and Cook County are rapidly increasing in population. At the last Federal census in 1920, the population was slightly over 3,000,000, and this has already increased to about 3,500,000. A study of this growth shows that the suburban areas surrounding the city are increasing much faster than the city itself. Since 1900, the time of the introduction of the automobile as a factor in our transportation facilities, the population drift has been steadily toward the cities and villages within thirty miles or so of the loop. In 1900 about 92% of Cook County's population lived within the city limits of Chicago, while in 1920 this had decreased to about 88%. This may be partially explained by the graph of the population per square mile, shown in Fig. 1. The population within the city rapidly increased to a high point of 14,000 per square mile in 1880, and during the next decade an area of about 133 square miles was annexed which more than trebled the area. Since then the density has increased until in 1920 it reached about the same point as in 1880. See Fig. 2. From this we may expect that either the city will again extend its limits or the suburban centers will increase more rapidly in population. The increase in the population in the outlying districts is more clearly shown in Fig. 3, giving the population per square mile of the county exclusive of the city. With the exception of the decade from 1880 to 1890 when the city annexed a large area, this growth has been continuous and gradually increasing in rapidity. As stated, this has been more marked since the introduction of the automobile.

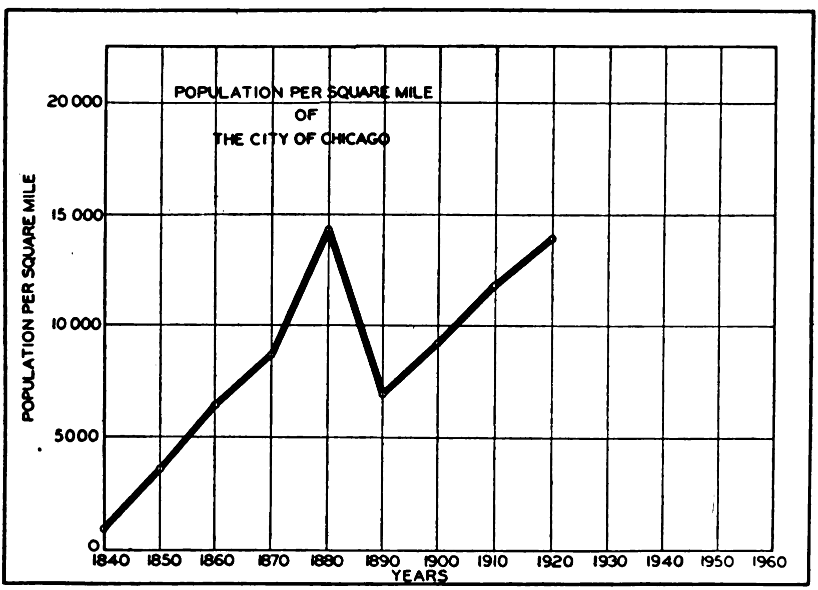


FIG. 2. DENSITY OF POPULATION IN CHICAGO IS ON THE INCREASE.

In regard to the number of motor vehicles which our highways must serve, as we all know, this growth has been phenomenal. With the exception of the war years, the growth has been continuous and at an ever increasing rate, until last year there were 350,000 motor vehicles in Cook County. The estimate of future growth is based on two factors, the increase in population and the increase in number of cars per capita. I do not share the belief in some quarters that the saturation point has been nearly reached. I think that the increase in cars per capita will continue until at least 1930 and possibly beyond that time.

What has been done to provide for the immense traffic movement that takes place in this county, and how are we planning to provide highways for the needs of the future? At the close of the 1924 construction season there had been built a total of 346 miles of pavement in the county. The dashed line in Fig. 4 shows the possible future construction by State and County of about 95 miles a year over a five-year period. Since 1920 the highway construction has not kept pace with the increase in automobile registration. See Fig. 5. Although in 1920 there were 1.5 miles of pavement per 1000 motor vehicles, this has dropped to only 1.0 mile in 1924. Even with the proposed 95 miles yearly program, by 1930 we would only reach the 1.5 mile mark again. In other words, such a program will do little more than keep pace with the rapidly increasing registration.

Facing such a situation, we decided to ask the best possible minds obtainable to act as consultants in the solution of our problem. The United States Bureau of Public Roads agreed to make a traffic survey of Cook County in co-operation with the Cook County Highway Department. Stations were established throughout the county where data would be secured. Of the 87 stations, 17 were designated as weight stations, 56 were recording stations and 14 in the city were called Chicago density stations. At all these stations extensive data were secured, except those stations within the city of Chicago, at which density counts only were made. Following is the data obtained from each truck passing the weight stations.

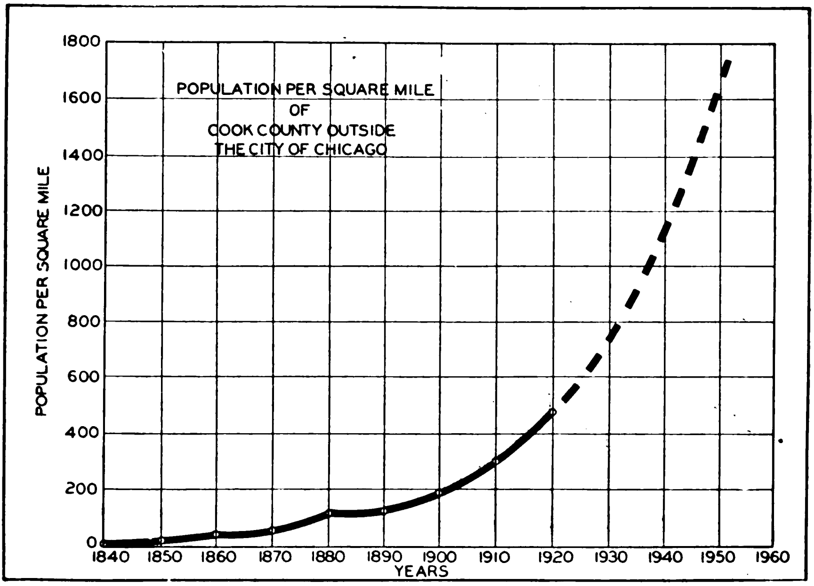


FIG. 3. DENSITY OF POPULATION IS INCREASING MORE RAPIDLY OUTSIDE THE CITY THAN WITHIN.

(a) Trucks:

Density per hour, State of License, Situs of Ownership, Make, Capacity, Body Width, Body Type, Origin and Destination, Type of Origin and destination, Total Mileage, Mileage over Cook County Highways, Trips per Week, Trip Time, Commodity, Packing of Load, Value of Load, Type of Trucking (Commercial Trucking Company or Owner Operator), Gross Weight, Front and Rear Axle Weights, Empty Weight, Net Weight of Load, Tire Type, Tire Size, Tire Depth, and Tire Impression on Pavement.

(b) Passenger Cars:
Density per hour.

(c) Other Vehicles:
Density per hour.

With the exception that no weights were obtained, practically the same data were obtained at the recording stations. The weight stations were occupied six days a month, while the recording and Chicago density stations were occupied three days a month.

The following extract sets forth the purposes of the survey. The information required to fulfill these purposes embraced not only the data obtained by the field parties, but also the results of some economic studies.

The Principal Objectives of the Survey.

To measure the amount and type of highway traffic on the Cook County Highway system and to record such information regarding this traffic as will aid in the solution of problems of (a) scientific and economical development of the highway system to serve traffic needs, (b) the relation of highway transportation to other forms of transportation, (c) the influence of the city of Chicago on highway traffic in Cook County and (d) to establish fundamental highway traffic principles.

I. Highway Administration and Engineering Data.

(1) Daily, hourly and yearly traffic flow and distribution on Cook County highways.

(2) Estimate of future traffic on Cook County highways.

(3) To determine quantitatively the relation of traffic to the economic factors producing traffic on the Cook County highways such as population, production, wealth and motor vehicle registration.

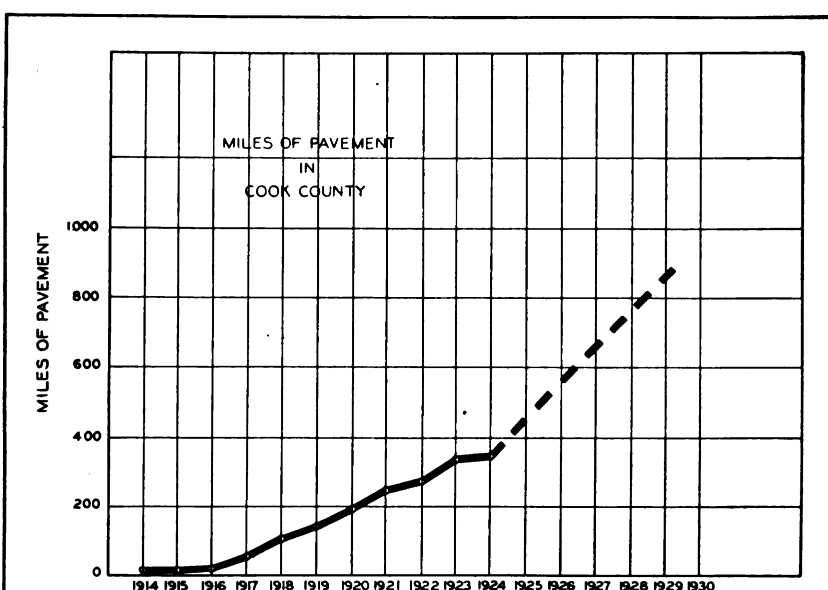


FIG. 4. MORE RAPID PAVING PROGRAM IS CONTEMPLATED IN COOK COUNTY.

(4) Classification of Cook County highways as industrial, high, medium or low type traffic routes based on (1) passenger car and motor truck density and (2) motor truck capacities, gross loads and wheel loads.

(5) Motor truck frequency and gross tonnage per mile of highway.

(6) To determine the maximum loading and frequency of critical loads on Cook County highways as an index of pavement width and design requirements of Cook County highways and to establish highway traffic width and design factors for highways contiguous to large centers of population.

(7) To determine the relation between highway width, traffic density and speed.

(8) To measure the effect of congestion at intersections and "bottle necks" upon the rate of traffic flow.

(9) To estimate the extent to which the improvement of old or the opening of new traffic routes is economically justified.

(10) Correlation of traffic loads and density on Cook County Highways with highway construction and maintenance costs.

(11) The type and volume of traffic on Cook County highways as an index to the allocation of highway construction funds.

(12) The amount and frequency of motor truck overloading, front and rear axle load distribution, wheel loading, tire depth and tire impression under load data.

(13) To compare the cost of various types of highway improvements such as relocations, grade reductions, elimination of grade crossings, (both rail and highway) and elimination of traffic "bottle necks" with the estimated saving in transportation costs resulting from such improvements.

(14) Comparison of the earning value of the Cook County highway system (based on passenger miles and freight ton miles) with the present worth of the Cook County highway system using replacement value minus depreciation as the basis of computing present worth.

II. Highway Economic Data.

(1) Highway transportation information concerning the volume of tonnage

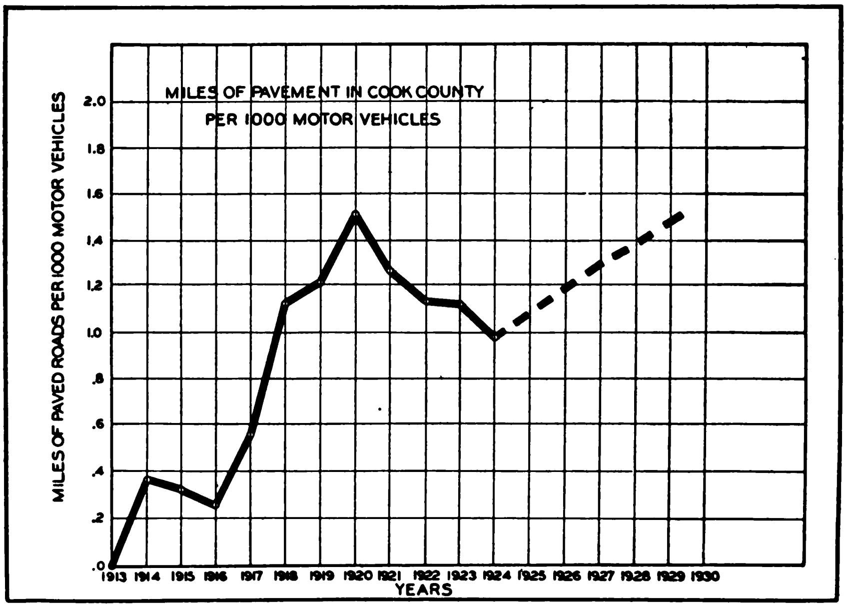


FIG. 5. HIGHWAY CONSTRUCTION HAS NOT KEPT PACE WITH THE NUMBER OF AUTOMOBILES.

shipped by motor trucks, marketing methods, and the relation of highway transportation to other types of transportation.

(2) To determine the mileage zones of motor truck haulage and the relation of the type of commodity hauled to such zones.

(3) The net tonnage of freight transported by regular and irregular trucking operators.

(4) The situs of ownership of passenger cars and motor trucks operating over the Cook County highway system.

(5) The actual or estimated value of motor truck net tonnage hauled over the Cook County highway system.

(6) The type of origin and destination as well as the origin and destination of net tonnage of commodities transported by motor truck over the Cook County highway system.

(7) Information concerning the relation of motor truck transportation to other methods of transportation particularly as to competition, rates, operating schedules and delivery time in the short, middle distance and long haul mileage zones.

(8) Data concerning haulage practices of motor truck operators and the volume of tonnage transported by motor truck between various cities and areas are of value to governmental agencies charged with the regulation and control of highway transportation.

(9) Passenger car business and non-business usage of Cook County highways.

One of the interesting facts brought out by the traffic survey was that approximately 125,000 vehicles pass the city limits every day through the thirteen entrances which are now paved. This is an average of nearly 10,000 vehicles per entrance, but of course some roads carry far more than their share of the burden. On a map of the state showing the roads which radiate from Chiago, with their feeders, it will be noted, that all the traffic originating in the southeast one-third of the state theoretically enters the city at Halsted Street, all from the central one-third on Archer Ave., while the rest of the state is better served, having several entrances to carry its traffic. I said theoretically, because an examination of the flow chart of total traffic, Fig. 6, shows that less than 20% of the traffic from the south uses Halsted St., while 80% of it enters the city over Western Ave. As all who are familiar with the locality know, this is due to the very poor condition of Halsted St. within the city limits and to the great delay caused to traffic by the grade crossing with the Indiana Harbor Belt line just south of the city limit. Here we have the condition of all this traffic detouring to Western Ave. and a great part of it coming back to Halsted St. farther north, a detour of four miles. A similar condition exists on Archer Ave. The traffic entering the city over that road is almost negligible, the motorists all preferring to take the detour which leads them back west across the river and north to Ogden Ave. Here they combine with the already heavy traffic from the west to make Ogden Ave. one of our most crowded entrances.

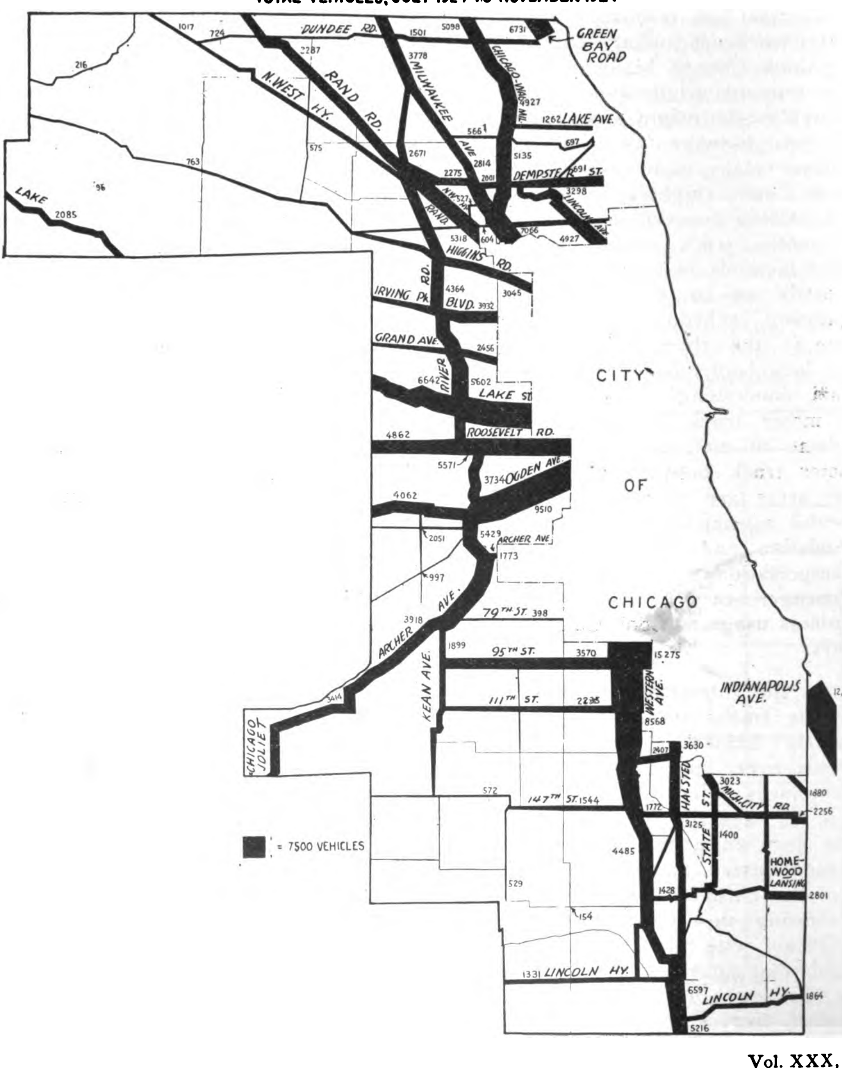
But nothwithstanding this condition of all the roads feeding into the city over a few entrances, it is not the traffic from downstate which causes the congestion on our highways. The present system is ample to take care of that movement. It is the traffic which originates within our own county that causes the congestion. Referring again to the south entrances to the city. The average daily traffic on the Dixie Highway in Steger at the south county limits was 5216 vehicles, while this had increased 260% by the time the city limits were reached, at which point Western Ave. and Halsted St. combined were carrying 18905 vehicles a day. Similarly on Lake St. near Bartlett, the average daily movement was 2085 vehicles, which by the time Melrose Park was reached had increased 220% to 6642 vehicles per day.

While the traffic survey was being carried on, we made some studies of our highway system as a whole without regard to pavements. To facilitate this study, the county and the surrounding territory was divided into twelve sections

each 17 miles north and south and 12 miles east and west. For each area two maps were drawn, one showing only the east and west roads, and the other only those running north and south. These show clearly how very few of our highways are continuous over even this small part of our county. The maps of section 11 (see Fig. 7 and Fig. 8) in the southwest part of the county illustrate this deficiency very clearly. This area is from the Dixie Highway west and you can clearly see that there are no through north and south roads in this entire area west of the Dixie and even that has a jog to the east of about one-half mile north of Chicago Heights. This section is but little better off in regard to east and west roads, there being no continuous roads between the Lincoln Highway at the north limits of Chicago Heights and 111th St. near the north boundary of the section, a distance of over 12 miles, and on 111th St. it is necessary to jog to

AVERAGE DAILY TRAFFIC-COOK COUNTY HIGHWAYS

TOTAL VEHICLES, JULY 1924 TO NOVEMBER 1924



the south about a quarter of a mile at 104th Ave.

Why are so many roads discontinuous? Because when they were originally laid out the need of through routes for fast moving traffic had not arisen and since that time the financial condition of the townships has not been such as to allow them to open many new roads.

Another reason why so few new roads are being opened is the very cumbersome process which has been set up by the Legislature, which must be followed in opening a road. Paragraphs No. 75 and 58 of the Road and Bridge Laws show the procedure it is necessary to go through. First, a petition of at least twelve land owners living within two miles must be filed, asking for such an improvement. Then if it is decided to

FIG. 6. FLOW CHART OF HIGHWAY TRAFFIC ENTERING CHICAGO.

open the road and an agreement can be reached with the land owners whose property is to be taken, it requires from eighteen months to two years before funds are available for payment of the claim. Paragraph 58 shows how this is carried out. As possession cannot be taken until payment is made, it can be clearly seen how long and laborious a procedure is necessary. The county itself has no jurisdiction to open any road unless such road lie on a state aid route.

Besides the legislative difficulties, there are several physical features which influence or determine the location of our highways. The main physical features in Cook County are the rivers. Running southwest from the city are three parallel

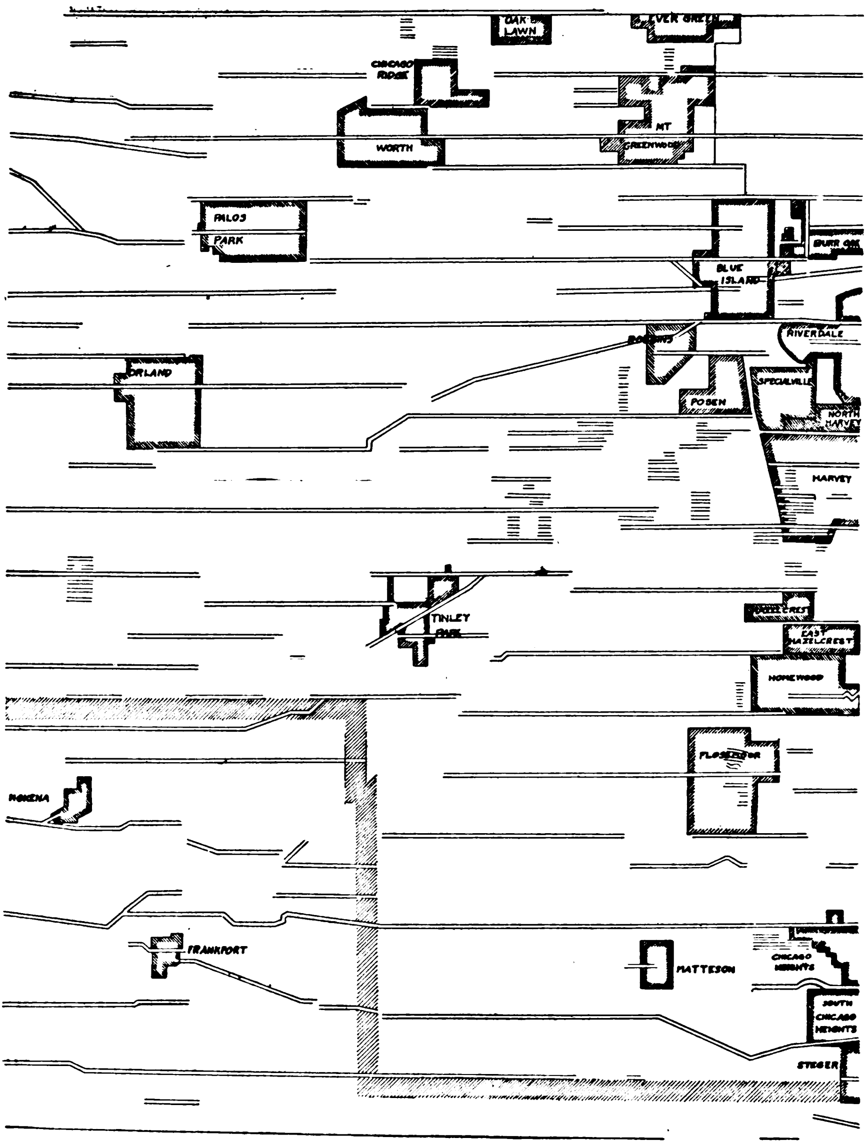


FIG. 7. MAP SHOWING ONLY NORTH-AND-SOUTH HIGHWAYS IN PART OF COOK COUNTY.

streams, the Des Plaines River, the Main Drainage Channel of the Sanitary District and the old Illinois and Michigan Canal. The location of a road across these streams is so expensive that at present in a distance of 20 miles there are only three crossings, one at Lemont, another at Willow Springs and the third at Summit. This factor limits the location of highways to a lesser extent all the way up the Desplaines River as far as Wheeling.

Chicago has become the greatest railroad terminal in the world and its railroads have been forced in many instances to place their large yards and shops outside the city limits. These yards are practically insurmountable barriers to highway location, as grade crossings are out of the question and the cost of either viaducts over or subways under multiple track layouts is prohibitive.

Another barrier that is rapidly becoming a very important one is the "special use area." A tract of ground once set aside for a cemetery or a golf club and which has been improved for such use influences in a large measure the location of our highways. Although such areas demand reasonable access to a paved highway, any attempt to obtain from them any right of way for highway purposes usually meets with strong opposition.

In the southern portion of the City of Chicago large areas have been improved with vast industrial plants. These demand highways for the transportation of their product, but as in the case of golf clubs and cemeteries are barriers to highway location which cannot be surmounted.

These factors are increasing in their importance as the years go on and we must either buy right of way in the near future for highway extensions which will be necessary, or devise some means of preserving rights of way so that when we are ready to purchase it, we will not find that expensive improvements have been placed upon it.

All these factors deserve and are receiving our earnest consideration in the laying out of an efficient highway system.

At the conclusion of traffic survey last December, a conference was held in Chicago of all the jurisdictions interested in highway development in the Chicago area. At this conference there were represented the United States Bureau of Public Roads, the State Highway Department, the Cook County Highway Department and the Chicago Plan Commission. An agreement was entered into providing that a plan for the Chicago Metropolitan District should be drawn up which would meet with the approval of all the jurisdictions mentioned, and after such approval no party would make any major changes in the plan without conferring with the other parties in an attempt to reach a solution satisfactory to all. No jurisdiction loses any of its sovereignty, because in the event that the conference fails to reach an agreement, any member can take such action as its sees fit. The agreement simply brings us together to unite our efforts so that future highway development will be on an efficient basis, the various bodies co-ordinating to produce the best system possible.

This is our problem and our method of attacking it. As to results, they will not be ready for some time yet, but we have high hopes that from concerted effort a system of roads will be built near Chicago which will serve efficiently and without undue congestion or delay the immense traffic which the future is sure to bring to the city gates.

Suburban Electric and Steam Railway Traffic

By Jesse S. Hyatt

Presented February 20, 1925

Development of suburban areas depends upon transportation which produces traffic of a nature entirely different from any other. This traffic which is described by Mr. Hyatt should be kept separate from other classes to permit it to flow without interruption to destination. Rates of fare must be adequate to support the service rendered. This statement of Chicago suburban business is timely.—Editor.

THE problems of suburban transportation is an old one. Ever since man lived in cities he has been devising ways and means to facilitate communication with the surrounding territory. In modern times, the changing social conditions brought about by the telegraph, the telephone, radio, and the automobile, make the subject an ever present study, and the methods and instrumentalities that were adequate yesterday will not meet tomorrow's needs.

In Chicago's suburban territory, that may be generally defined by a line through Waukegan and Crystal Lake on the north, Elgin, Aurora and Joliet on the west, and Chicago Heights, Blue Island and Gary on the South, the present towns were largely centers of population at a very early period and all have had independent natural sources of formation; but the development of the suburban territory as a whole has been from these centers towards Chicago, and outward from the Chicago city limits, thus tending to fill in the intermediate territory between Chicago and these outlying suburban centers. The extent of this area cannot be largely increased without more rapid means of travel; hence we may expect the growth to continue by filling in rather than by expansion, although we can reasonably expect this area to expand to the Wisconsin State Line on the north, Michigan City on the southeast, and westerly to an arc of at least fifty miles radius from the present business center of Chicago.

Mr. Thurston, of the Illinois Bell Telephone Company, estimates that in 1950 our suburban territory will have a population of 2,141,000. The Chicago Commerce, however, in its issue of January 10, 1925, states that the metropolitan area outside of the present city limits can reasonably be expected to have in 1950 a population in excess of that of the present city area. As nearly all the estimates of the 1950 population within the present city limits are in excess of 5,000,000 people, this would make the latter estimate greatly in excess of the former, but the larger estimate is based on the present trend of population towards the suburbs, due largely to the more general use of the automobile and the greater area available.

The suburban territory has naturally grown along the arteries of travel but the greater influence of Chicago itself has caused this growth to be almost wholly along arteries of transportation radiating from the city. Belt lines and cross-country railroads have not succeeded in developing any considerable population independent of the radial transportation lines from the city proper. The following table showing the actual and estimated growth of population in the suburban district and that served by electric railways and steam railways indicates that the majority of this population is so distributed.

Year	Served by Elec. Railways	Served by Steam, But Not by Elec. Rys.	Total Served by Steam and Elec. Rys.	Total of Territory
1900	197,416	71,935	269,351	394,308
1910	338,459	97,824	436,283	567,537
1920	501,751	163,240	664,991	820,084
1950	1,125,000	366,000	1,491,000	2,141,000

The earliest suburban service was of course that of the steam railroads, the Chicago and Northwestern Railway, the Illinois Central Railway, the Chicago, Burlington and Quincy Railway and the

Chicago, Rock Island and Pacific Railway all being pioneers in the development of this method of transportation.

This traffic was never directly profitable but was considered by the railroads as an indirect benefit, as this service was necessary to the proper development of the city and reflected the benefits to the carriers through increased freight transportation by the increase in manufactures and the establishment of commercial enterprises. Rates were established, not with any idea of their adequacy but with the idea of building up the territory.

Electric interurban lines were established by power companies in the suburban district for the same purpose, that is, to build up the territory and to provide a more even power factor for their generating stations. Some interurban lines, however, were developed independent of power companies through a false estimate of the adequacy of the suburban rate and the economy of electric traction. As a natural consequence, the suburban business has so developed around Chicago as to become a very apparent burden to the steam carriers and has forced the weaker electric traction companies who had no other source of recouping their losses to higher rates of fare.

Terminal and traction reports prepared under the direction of the Chicago Chamber of Commerce and the Chicago City Council show that in the decade from 1900 to 1910 the suburban steam traffic did not increase quite in proportion to the increase of population in the suburbs, and that the electric suburban traffic during this period was quite inconsiderable, while during the decade of 1910 to 1920 the steam railway suburban traffic has grown much in excess of the population in the suburban territory even though the general traffic movement in this period has been supplemented by high speed electric lines handling nearly one-third as much traffic as the steam roads.

Today six steam roads give the bulk of the suburban service. Eighteen or twenty others give suburban service in a very limited way. Three electric interurban lines enter the loop area. Three or four others extend the city rapid transit or surface lines into the suburban district.

Serving the northerly suburban territory, there are now 145 trains daily, 65 being on electric lines and 80 on steam roads; in a westerly direction, 268 trains daily, 84 on electric roads and 183 on steam roads; in a southerly and easterly direction, 417 trains daily, 23 on electric roads and 394 on steam roads, making a total service of 830 trains daily, 173 on electric roads and 657 on steam roads.

Today's suburban service demands high speed and frequent headway, with convenient delivery and pick-ups. Few, if any, of the present carriers are ideally equipped to meet this demand. Many of the roads must operate their suburban service sandwiched in between a heavy trunk line passenger service and an even heavier freight traffic. Some of the terminals do not lend themselves to convenient delivery, requiring their patrons to walk long distances to their places of business or to utilize some other means of transportation to their final destination. Through traffic a very important element in the city's growth, is frequently interfered with by the suburban service.

While the rate of growth of traffic, as shown by the history of the past decade, cannot be relied upon with certainty in foretelling the future, yet all the indications of the present trend point to a demand on suburban facilities which will be in increasing proportion to the increase of population. Many see in the movement of business to outlying district and suburban territories and in the increased use of the automobile a decrease in the demand on the railroads or suburban facilities, but a careful scrutiny of the statistics of the past few years will not bear out this conclusion. Just as the building of rapid transit lines, suburban electric lines and street car lines has increased the traffic for steam roads, so will the automobile and the motor truck.

Residential areas will be developed further from the business center of Chicago, while minor centers of commerce

will undoubtedly be located in outlying or suburban centers more directly contiguous to residential sections of population. Suburban traffic will probably continue to increase in greater ratio than the population. These conditions will require a more rapid and frequent suburban service between Chicago's business center and the outlying residential and commercial centers; hence the demand upon steam and electric interurban lines will grow in ever increasing proportions. The automobile, on account of its inadequancy for mass transportation will be used only to a limited extent between these centers and will find its main field of usefulness as a feeder to suburban lines.

Because of the greater distances involved and the greater demands made, improvements in speed and headway and convenient pick-up and delivery are essential to the prosperity and usefulness of the suburban steam and electric railways. Each road has its own particular conditions and must meet the solution of this problem in accordance with its own limitations and needs, but in general the following principles will apply.

The greatest development in suburban territory will be along existing rail routes of transportation radial to the business district of Chicago, and these routes should be developed in the interest of economy to the highest degree for mass transportation. All population centers are and naturally will be on steam or electric lines radial to Chicago's business district. Mass transportation will always be between these centers of population. The automobile and hard roads will provide largely for lateral transportation and for the development of territory between rail routes, where the rail routes are not too far apart for convenient and economical transportation by this means.

Conditions brought about largely by the advent of the automobile emphasize the need of rapid transit suburban service with frequency of headway paramount and speed a close secondary consideration. Suburban service is a special type of transportation requiring treatment essentially different from through long-haul passenger service or through or local freight traffic, and to serve adequately either type of traffic they must be treated separately, but in the interest of economy, co-ordination should be carried out to the utmost extent.

These conditions can be met best by the following general changes: Suburban service should be routed through the congested downtown area to lay-up or terminal yards beyond, and not routed back from a terminal in the down-town area, which involves the delay and inconvenience of turning trains and does not give as wide a distribution of delivery. Convenient transfer or connection points should be arranged with rapid transit city lines so as to give a wider distribution of delivery. In the area of pick-up and of delivery, suburban service should be routed on independent tracks so as not to interfere with the through traffic of the steam carriers. The more rapid acceleration and deceleration of the multiple unit electrical control should be employed to greatly increase the speed and safety of operation, thereby loading expensive terminal and right-of-ways to a point where suburban traffic may become profitable to the carrier. Where practical, industries should be located largely to one side of the right-of-way. The opposite side of the right-of-way being devoted to suburban business, thus preventing the interference of freight traffic and suburban passenger traffic.

The rates of fare should be increased to make suburban traffic self-supporting. President Markham's recent statement clearly puts the fact before the public that steam railroads are operating suburban service at a loss, and it is economically unsound and essentially unfair that other types of traffic should make up this loss. The organization of granger interests will undoubtedly force the correction of this evil if the metropolitan areas do not admit their mistake that it is much better to clean your own house than to have someone do it for you. Interurban roads in our own territory have learned the lesson of the folly of inadequate fares and are keeping fares at a point that will pay a return on the investment, satisfying the patron by

more frequent and efficient service. Uneconomical methods of operation must be discarded. The public will not pay adequate fares for inadequate service or for wasteful operation. Power systems that are adaptable and economical for close headway traffic should be adopted. train control that permits convenient and economic adjustment of the seating facilities to the traffic should be employed. Existing facilities should be used to the utmost. Private rights-of-way should be studied and so adapted that all available space may have the utmost possible use.

The trend of the future is towards greater suburban traffic between greater centers of population, served by adequate rapid transit train movement uninterfered with by other forms of traffic at points of pick-up and delivery along existing routes, utilizing the present facilities to the utmost. Suburban service will be made convenient by frequent pick-ups and well distributed deliveries, operated in an economical and efficient manner, for a rate of fare that is adequate and self-supporting.

Urban Transportation, Rapid Transit and Surface Lines

Development of Existing Urban Transportation Systems of Chicago and An Outlook Toward Future Requirements and Developments

By CHARLES V. WESTON*, M. W. S. E.
Presented February 20, 1925

This review of the local transportation question gives an excellent picture of the growth of the tremendous system now required by Chicago and its probable future extension. Enormous capital expenditures will be necessary to keep pace with the demands expected to be made upon it. This will continue to be a major factor in the development of the city.—Editor.

THE transportation problem of Chicago has become dog-eared from much handling and in the volumes of discussion throughout the years, apparently little has been left unsaid.

Yet we must continue to discuss it, because it is the most important question before the people of Chicago and it must be solved adequately and soon if the city's growth is not to be retarded seriously.

The transportation agencies and the streets, under existing conditions in certain localities have practically reached the saturation point. Normal growth in population means enormous increase in the demand for extended facilities and more street space. In twenty-five years there should be at least two million more people in Chicago than there are now and the area of the city will stretch out over many more square miles.

Two billion revenue riders must be carried annually, most of them for longer distances than they are carried today. How is it to be done?

The answer must be found without much more delay.

Local transportation has been the most important factor in the sociologic and economic development of all cities of either major or secondary magnitude.

No matter what natural advantages lead men to settle in any locality and undertake the development of community activities and industrial enterprises, success both for the individual and the community is dependent upon the establishment of efficient local transportation facilities.

Population inevitably follows the line of transportation. Property values are immediately advanced when transportation lines are projected into new territory. All other public utilities, such as

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gas, electric light and power service, telephone, etc., usually follow the installation of the transportation line which produces density of population and a consequent demand for the other necessities and refinements of living.

The real growth of the City of Chicago began in 1858 with the introduction of the first street railway. The area of the city was approximately twenty square miles and its population about eighty thousand, giving an average density of four thousand inhabitants per square mile of area. All future development of the city in respect to the distribution of population and the creation of wealth followed the lines of the street railways as they were projected into new territory from time to time.

After the advent of these transit facilities the growth of the city was phenomenal. During the following twelve years the population was practically quadrupled, and, during the sixty-seven years that have elapsed since the beginning of street railway transportation, Chicago's area has increased more than tenfold and its population is more than thirty-seven times greater.

In the thirty-two years from 1858 to 1890, the area of the city had increased from twenty square miles to one hundred and seventy square miles or 750%, an average rate of 23.44% per annum. The population during that time had grown from approximately 80,000 to 1,099,850, an increase of 1275% for the period, at an average rate of 40% per annum. The large and often astonishing increases in the city's area and population were due to annexation of populated incorporated territory, contiguous to the city proper, which had developed simultaneously with the area bounded by city limits lines.

During the period 1890 to date, the expansion of city area has been less rapid, the present area being approximately 209 square miles, an increase during the last thirty-five years of 39 square miles or 22.94%, an average annual rate approximating 0.59%. Population increased from 1,099,850 to more than 3,000,000, or approximately 173%, for the period at an average annual rate of 5.4%.

Estimating on the conservative basis of 2% annual increase in growth during the next twenty-five years, the population within the city limits of Chicago will be 5,000,000 in the year 1950.

Have the surface street railways of Chicago since their initial installation rendered reasonably adequate service to the community? Statistics, so far as they are available, indicate that they have, in spite of the restrictions that have been put upon them by ordinance, politically and otherwise, particularly during the last twenty-five years.

In the earlier period of their existence when over-optimism in respect to the possibilities of returns prevailed, they were over-built and over-serviced and carried financial losses in new territory until the density of population was sufficient to yield the cost of operating the cars and maintaining the roadway and equipment. Property owners, the riding public and the state, during those periods when the companies were carrying the burden of losses, profited enormously.

As roadway and equipment became obsolete through development of the art, Chicago's street railway operators have ever been foremost in scrapping the old and adopting the new, and they have in many respects set the pace for the country at large in the improvement of urban transportation. Their standards of physical construction as to roadway and equipment and as to operating methods are of the most advanced type.

Briefly, the development of the great system of local surface street railways which Chicago now possesses may be chronologically stated as follows:

In 1859 car tracks were laid upon 9 miles of city streets. Early growth was not rapid.

In 1866 there were 29 miles of streets carrying street railway tracks, and in 1876 but 54 miles. In successive years the mileage was as follows: 1886, 131 miles; 1896, 344 miles; 1907, 358 miles; 1916, 475 miles; as of this date there are 533 miles. In general these figures may be multiplied by two to give the miles of single track. As of the present date the single track mileage of the system is 1071.

The transition from the original strap rail track laid on longitudinal timber stringers, and the diminutive single truck bobtailed car hauled by a single horse to the modern double truck car propelled at high speed by electricity on tracks laid with steel girder rails weighing 131 pounds per yard, placed upon rigid concrete foundations, stated in chronological order, has been as follows:

1859—ground broken at State and Randolph Streets for the first horse car line.

1864—Steam dummy running on Evanston Avenue (now Broadway) from Diversey Avenue to Graceland Cemetery.

1881—Steam dummy running on Cottage Grove Avenue from Oakwood Avenue to Fifty-fifth Street and on Fifty-fifth Street east to Lake Avenue.

1882—First cable line began operation on State Street as far south as Twenty-second Street.

1887—The tracks of the North Side lines extended as far as Irving Park Boulevard by way of Clark Street and Evanston Avenue (now Broadway); the South Side lines as far as Fortieth Street; the West Side lines as far as Garfield Park.

1888—March—First North Side cable line on Clark Street to Diversey Boulevard.

1890—July—First West Side cable line on Madison Street.

1893—First overhead trolley line put in operation on the South Side by Chicago City Railway Company.

1894-'95-'96—Various other lines electrified and numerous extensions were built.

1906—All cable lines changed to overhead trolley.

1907—Feb. 11—Settlement ordinances were passed affecting the surface lines and providing for through routing cars over the various systems.

1914—Unified operation of all surface lines in the city with a single rate of fare and universal transfers became effective.

The most outstanding feature of the development of street railway service in Chicago was the transition from cable propulsion to electrical propulsion which had a very marked effect in increasing the rapidity of car movement, thus making possible a more effective distribution of the rolling stock over the system.

To illustrate the effect of this substitution of electrical propulsion compared with the former methods which it displaced: In 1896, when the electrification was well on its way toward completion, the annual car mileage of the system was 51,143,966, with 2607 cars available for service; the average annual mileage per car was 19,618. As of year 1910, the annual system car mileage was 92,734,508 with 2,763 cars available for service; the average annual mileage per car was 33,563. As of year 1920, the annual system car mileage was 116,972,503 with 3,169 cars available for service; the average annual mileage per car was 36,911. For the year 1924, the system car mileage was 126,687,097 with 3,515 cars available for service; the average mileage per car therefore being 36,041.

The average number of seats per car in 1896 was 25.12. In 1910 the seats per car averaged 38.32. In 1920 the average was 42.77 and as of the present time the average is 43.93 seats per car.

In 1896 the combined systems carried approximately 250,000,000 revenue passengers supplying 1,284,735,672 seat miles, or 5 seat miles per revenue passenger. In 1924 the unified system carried 829,700,000 revenue passengers supplying 5,565,364,215 seat miles or 6.7 seat miles per passenger.

From the foregoing statement it will be seen that in spite of the enormous and constantly increasing difficulties that are ever present due to traffic congestion on the streets, and the necessity for moving a majority of street car riders during a very few hours in the morning and evening rush periods, the measure of service rendered has been steadily increasing and these accomplishments have been effected in the face of constantly increasing costs of labor, materials and supplies, and during recent years in largely decreased purchasing power of the dollar. Under such conditions improvement in service could be attained only through vigilant and effective effort on the part of a skillful management.

The Surface Lines of Chicago represent an actual investment exceeding $163,000,000 and they could not be reproduced, as of this date, for a sum in excess of $200,000,000. Improvement in plant has cost $110,000,000 since 1908.

To illustrate what efficient management is accomplishing for the car rider in Chicago, in the face of the diminished purchasing power of the dollar, a little analysis of the situation may be interesting. The companies are now serving 830,000,000 revenue riders per annum for a cash fare rate of 7 cents. The present value of the dollar compared with its pre-war value is about 64 cents. The required fare to equal the pre-war 5c fare is 7.81 cents. Interest on the cost of the plant improvement at 6% per annum equals 0.8c per passenger carried, which added to the 7.81 cents required to equal pre-war 5c fares, equals 8.61 cents the fare required to be equivalent to a 1908 fare. The difference between the present fare charged and the equivalent fare is 1.61 cents which, multiplied by 830,000,000 revenue riders equals the sum of $13,363,000 saving to the public annually and in addition the Companies contribute for public benefits $6,344,000.

The transportation situation in Chicago, so far as street railways are concerned clearly is this: The City has a system representing the highest degree of physical perfection. It is well managed and efficiently operated. The measure of service rendered is now approaching very close to the maximum that is humanly possible until action has been taken which will open the way to provide for undertaking a very extensive program for enlarging the facilities. This program must be based upon a well thought out plan looking into the future for at least a generation and visualizing in a broad and practical way what will be necessary to take care of future great demands.

In respect to existing rapid transit facilities, Chicago's system of elevated railroads is a splendid example of that type of transit facility. It is well managed and efficiently operated as a system entirely separated from and in competition with the surface lines and too, perhaps in a still greater degree than the surface lines, has reached practically the maximum of service that it can render under its present limitations. It must be enabled to provide relief through additions to its facilities following a comprehensive plan for city-wide transit, looking toward the co-ordination of all local transportation agencies insofar as they lend themselves to co-ordination.

The future of the urban transportation systems of Chicago will depend entirely upon what is done in the way of making it possible to finance the very large capital investment required to supply the extensions, betterments and additions that must be made to meet adequately the demands of a constantly increasing population and riding habit during the next twenty-five years.

Conservative estimates indicate that Chicago's urban population in the year 1950 will be in excess of 5,000,000 people, and that the riding habit of that population will probably exceed 400 rides per capita per annum. This means that during the year 1950, transportation by street railway and rapid transit lines must be supplied to accommodate more than 2,000,000,000 revenue riders—practically twice the number of revenue riders now being carried per annum by those systems.

The new capital investment that will be required to create the necessary improvements, additions and extensions to these systems of transportation during the twenty-five year period under consideration, estimated on conservative bases, will amount to at least $250,000,000 or an average rate not less than $10,000,000 per annum, which would bring the total capitalization of the enterprise, at 1950, to a sum in excess of $500,000,000.

In order to bring these systems of transportation to the condition of adequacy the present situation demands, and to anticipate reasonably future demands covering the period of a decade, nearly half of the estimated capital expenditures required to be made for the twenty-five year period must be expended during the first six or seven years.

To carry this very large capital investment and to provide for its ultimate return to the investors, to secure that measure of service to the public which it is entitled to receive and to meet all legitimate operating expenses, the gross earnings must be sufficient to pay for these requirements. On the basis of 2,000,000,000 revenue riders in the year 1950, the gross revenues required would lie somewhere between $155,000,000 and $160,000,000.

It is evident, as has been demonstrated by past experience, that annual requirements for revenue will fluctuate and that a pre-fixed fare would be disadvantageous to both the car riders and to the investors, and that the only acceptable method of fixing rates would be by the now generally accepted method of service-at-cost, under proper public regulation.

Many studies have been made by engineers and others skilled and broadly experienced in such matters, demonstrating that if the operation of these properties were properly co-ordinated so that the maximum economies and efficiency could be made effective, ample revenue could be earned to cover all the requirements mentioned at approximately the present average rate of fare, including transfers between the different types of service. This would accomplish the long sought ideal of one-city-one-fare with universal transfers.

The Parsons-Ridgway-Arnold report of 1916 developed this idea, presenting in detail physical features of a plan for unification and development of transportation facilities quite in line with the best thought on the subject today. As pointed out in that report, unified operation of surface and elevated lines and subways is essential to an adequate solution of the problem. Without this coordination maximum service, even under the most skillful management, can never be realized.

Duplication of effort, over-service of some communities and under-service of others and high cost of service due to lack of transfer privileges cannot be avoided under existing conditions.

It is important, also, that the inevitable relationship between urban and suburban facilities shall be considered in connection with unification.

The great metropolitan districts, rapidly spreading north and south and west, will pour a constantly increasing stream of commuters into the city daily. In the unified system there must be direct and convenient contact at terminal points between suburban lines and rapid transit lines with sufficient capacity on lines inside the city to take care of suburban growth.

The underlying principle which should govern the planning of a comprehensive, co-ordinated transportation system should be the establishment of rapid transit lines radiating in every direction along natural trunk line routes and the use of surface lines and supplementary bus service largely as feeders to the rapid transit lines.

Subways must be built in the loop both for rapid transit and some surface cars. Owing to the comparatively small area covered by the congested section of the city, however, the subways, in the beginning at least, need not be very extensive. A four-track tube in State Street, a two-track tube in Washington Street from Grant Park to Union Park and another two-track tube from Grant Park to Franklin Street, connecting with the Van Buren Street tunnel, would take care of immediate needs. The State Street subway could be used both by rapid transit and surface cars and the east and west subways by surface cars.

Rapid transit lines for the immediate future should consist of elevated structures except in the loop area where the subway would be used.

Under this plan it has been estimated that approximately $106,000,000 must be spent in construction and co-ordination during the first six years following unification. Of this amount $40,000,000 would be required for subways, $44,550,000 for construction and equipment of rapid transit lines and $22,000,000 for construction and equipment of surface lines.

A program of this magnitude would insure the building of sufficient exten-

sions both of rapid transit and surface lines to provide transportation for all the centers of population now in need of service, and the establishment of bus routes for those sections whose populations are not sufficient to warrant track construction.

Subways are essentially public thoroughfares made necessary by the lack of street capacity to take care of all the traffic. Manifestly, therefore, they should be built by the city and used by transportation agencies under agreement with the city in much the same manner in which the streets are used. The fund contributed by street car riders in the form of 55 per cent of the net receipts of the Surface Lines is available for this purpose.

As to the best method of carrying out the general plan of unification and providing the money necessary for improvements, opinions differ. The city administration's theory is expressed in an ordinance now pending. There are others who believe the same ends could be accomplished more quickly and with better results by private management under public regulation. These latter point out that with an extension of the franchise period, terminable at the city's option to buy, with public regulation by the State Commerce Commission and municipal partnership on the Board of Operation, and with an amortization fund set aside out of earnings to buy the lines for the city eventually, the people would have all the advantages of publicly controlled transportation without any of the risks or responsibilities entailed by municipal operation.

Without going into the merits of the two views or participating in any way in the political discussion regarding the pending proposition, it may be stated safely that regardless of the manner in which unification is accomplished, the unified system, once it is complete, must be managed only by skilled executives free from the exigencies of politics and independent of the demands of political bosses. Otherwise efficiency will be an impossibility.

A system representing half a billion dollars in capital, earning a hundred and fifty millions a year and employing many thousands of men, cannot become a pawn in the game of politics without being seriously handicapped in serving the people. Any weakening of the efficiency of such a system not only would be immediately felt by patrons, but must inevitably result in deficits which would be reflected in the form of municipal taxes.

There is comfort in the fact that the people of Chicago now recognize the necessity for an early settlement of this age-old problem. The emergency is more apparent today than it has ever been.

Chicago is nosing into the position of third city in the world in size. Situated as it is, there is no natural barrier in the way of unlimited growth in population and extension of area. Its phenomenal expansion in a few decades from a village to the present great metropolis need be no more remarkable than its future growth.

But to attain the preeminence to which its destiny seems to point, it must have adequate transportation and transportation systems cannot be built in a day.

This apparently is fully realized by the general public and the demand that something be done at once towards the digging of subways and the settlement of the entire transportation question is heard on every hand. It is not so important that there is a difference of opinion as to what should be done and how it should be done.

If there is sufficient conviction that action is necessary, the way will be found.

There are available two of the most efficient properties of their kind in the country. Only the will and ability to make of them a unit fully co-ordinated and extended is needed to give the city the greatest transportation system in the world.

The Fundamentals of Terminal Building

By MAJOR RUFUS W. PUTNAM*, M. W. S. E.

Presented February 19, 1925

This paper reviews some of the factors that must be taken into account in designing a terminal to serve its purpose well. Harbor plans, land facilities, storage plants, type of carriers, relative costs and relation to city plans are discussed from the standpoint of general efficiency of the whole development. Chicago is fortunate in having most of the primary requisites for a great terminal at moderate cost.—Editor.

The Significance of Regional and National Influences

IT HAS been said that the supremacy of a large terminal is dependent on three factors: First, the tributary commerce, actual or potential; second, the physical characteristics of the site; third, the efficiency of the terminal facilities. The first factor is inherent in the physical structure and configuration of the surrounding country, and depends upon climatic conditions, none of which may be largely influenced by works of man except by way of making accessible and developing the natural resources. The existence of an actual or potential tributary commerce is what creates the terminal or a demand for one; hence to this extent the terminal is the beneficiary of and dependent upon the hinterland behind it. A rich hinterland capable of supporting a large population and producing an excess of agricultural, mineral or manufactured products is fundamental.

In order that the characteristics of the hinterland back of a terminal be visualized clearly, terminal planners should not fail to look beyond the confines of their own locality. Sometimes they forget that when a terminal has reached a size where well-thought-out planning is necessary it is more than self-contained and self-sufficient, that it has a sphere of influence which is regional or perhaps national in extent. As a result, the part the terminal is to play in the regional and national scheme of development is not included or is improperly assumed in the working out of its plan. The consequences of such an error are not generally immediately apparent and sometimes as much as a generation passes before indications of it are in evidence.

There are certain forces at work, regional or national in scope, which enter into and vitally affect the welfare of any terminal of importance. In a great many cases they are the very forces which are responsible for the existence of the terminal, constitute its very life-blood and can be disregarded or interfered with at its peril. In other instances, while less vital to existence, they present opportunities in the way of increased prosperity which hardly can afford to be neglected.

A terminal plan, therefore, should begin with a study of the history of the locality, economic rather than political, and an examination into the forces which have governed its existence and guided its growth. As regards these forces no effort should be spared to learn their characteristics, their limitations and possibilities, their advantages and disadvantages. They should be followed from source to destination and not left till thoroughly understood and provided for. Obviously, neither an architect nor an engineer is *per se* qualified for researches of this character. Such investigations require a thorough grounding in economics.

To visualize properly the extent of outside influences upon a locality and the effect these influences may have on a terminal consideration must be given to the science of regional planning or building. Like city building, this science is the result of necessity, the necessity for maintaining direct and adequate highways of communication, for separating residential from industrial and

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commercial development, for providing suitable and ample parks, playgrounds and other recreational features, and for taking advantage of all the commercial and industrial potentialities of the region. Here it is necessary to understand thoroughly the true place the region is to take in the affairs of the nation. A district does not need the assistance of regional planning unless it is of sufficient importance to have a decided influence on the welfare of the whole country. If governing conditions and the sphere of influence are not studied and the lessons learned applied to the regional plan sooner or later it will be found that country wide considerations have entered in to upset it; or perhaps that local developments have come about in such a way as to interfere vitally with the growth or operation of activities of national significance.

The idea of a national plan is comparatively new. The term nation building is but little used, if at all, for there is no such system actually in existence. There has been no systematic opening up, development, and exploitation of new sections of the country in accordance with fixed principles or an established plan, no more than there have been comprehensive city plans guiding the growth and upbuilding of cities from their very beginning. Yet, practically every city of importance has found it necessary to have a plan prepared and set up as a guide to prevent the recurrence of conditions which tend to interfere with healthy growth. Would it be too much to presume that the time is approaching when *impasses* in the way of inadequate transportation facilities, excessive costs of fuel, insufficient supplies of power, and other vital contingencies of a similar nature will require the substitution of a national plan for opportunist development in the same way rational city plans have supplanted mushroom, promotional, or abortive city growth? It is not the purpose here to argue the creation of a national Plan Commission or the adoption of a national plan. The object of this discussion is to stress the importance of taking into consideration influences which originate outside of the particular locality in question whenever any important phase of city building, (which terminal building undoubtedly is) is being studied. A further purpose is to stress the point that the welfare of a large port or terminal is more than a matter of local significance. The entire hinterland back of such a port is interested. Costs of transporting imports and exports depend considerably upon the efficiency of the terminal through which handled, and in like measure, the economic welfare of the interior.

The Influence of Physical Characteristics

The second factor which contributes largely to the supremacy of a great terminal has to do with the physical characteristics of the site. Favorable topographic conditions such as easy grades, workable soil, adaptable layout, and the like are very much to be desired. It is true that engineering operations may overcome any or all obstacles which the physical characteristics of the terminal site may offer, but where these obstacles become of serious proportions the costs of improvement may be so great as to entirely preclude the development of the site or at least to interfere with it.

In designing a terminal its fundamental purpose must not be overlooked. Irrespective of character of freight or cargo, classes of carriers, and transfer agencies, the sole object of a terminal is to facilitate the loading and discharge of passengers and cargo, or their transference between carriers where that is made necessary by the conditions of the journey. Line-haul efficiency, either by rail or water, has been highly developed. The task for the future is to ease the transfer between carriers or lines; this should be the one aim of the terminal engineer in the design of a terminal.

Few terminals, if any, have been built to order. In general, it is not possible to use a templet with which developments of channels, piers, wharves, yards, stations, freight houses and other auxiliaries may be made to conform. The

physical characteristics of the site have a great deal to do with the plans adopted and the methods of construction followed. The terminal engineer, although following certain precepts of general application, must rely largely on his ability to adapt local conditions so that the most favorable development may be realized.

Harbor Plans

In planning the general lay-out of a harbor the determination of the type of shore accomodation for ships that is best adapted to the physical characteristics of the site is one of the first steps. Wharves are generally the most suitable type of construction along a river front, or elsewhere if the channel is narrow. Piers are suitable in places where excavation is difficult, where depths are not too great, and the fairway is of sufficient width to permit the encroachment. Quays are economical if land adjacent to the water-front is not too expensive and excavation is comparatively easy. All three types may be made equally efficient for the transfer of passengers or cargo. The quay and the pier permit a more intensive use of the water-front. The pier requires less ownership of valuable land than either the quay or wharf. For industrial harbors requiring more land area than water area, the quay is generally the best type of construction.

In some ports, the range of tides is an important consideration and often requires special construction, such as basins and locks. In this country, the tidal range is not great enough to have an important influence on the design of port or terminal facilities. An equally serious situation, however, is the fluctuation of levels of certain rivers that form a part of the inland waterway system of the United States. Variations as great as 60 feet have been noted and average yearly variations in some places are in excess of 30 feet.

It is no great handicap for a port to be situated at some distance from the sea. If, by eliminating an extra handling, or by making it possible to use a better harbor site, or by bringing the water carrier to the natural cross-roads of land highways, a port is located a distance inland, there is no reason why it should not thrive as far as its position with respect to the sea is concerned, provided the difficulties of maintaining and of navigating the connecting channels are not too great.

Several well known ports of the United States are well inland, of which the following are examples: Baltimore, Md., 151 miles; Portland, Ore., 112 miles; New Orleans, La., 106 miles; and Philadelphia, Pa., 105 miles.

Some of the inland ports are: Hamburg, Germany, 67 miles; London, England, 67 miles; Bordeaux, France, 60 miles; Manchester, England, 54½ miles; Bremen, Germany, 54 miles; and Antwerp, Belgium, 50 miles.

It is not necessary that the harbor site be very large, although ample anchorage space is desirable. This space may be in the form of a basin or a long wide channel connecting the port with the sea. If ports are developed so that intensive use is possible, relatively small dock space is necessary as compared with present American practice. Well equipped European quays average more than 1,500 tons of cargo per foot of quay per year. At New York City, the average is 150 tons. For a commerce of about 30,000,000 tons per year of a general character 30,000 ft. of well equipped docks would suffice if the annual rate were 1,000 tons per ft. Compare this to the total length of water-front in the following cities: New York City, 921 miles; Boston, Mass., 141 miles; Baltimore, Md., 120 miles; Seattle, Wash., 114 miles; and Chicago, Ill., 67 miles.

In addition to providing sufficient water area for anchorage purposes and water frontage for dock purposes, a port site also must provide ample space for the land facilities, notably transit sheds, warehouses, open storage yards, and railroad connections and yards. There is no rule by which this land area may be determined as it depends on the kind of freight handled, the length of the navigation season, duration of crop

periods, efficiency of rail service, and many other considerations, all of which must be determined for the particular problem. However, a fundamental requisite is that this land area must be immediately adjacent to the improved water-front, and as near it as possible without the facilities thereon interfering with the service of the water carriers.

On account of the greater flexibility of rail equipment and the structures involved it is generally simpler as far as these features are concerned, though by no means less vital, to alter topographic conditions to meet the requirements of the terminal. Almost any site which is not too hilly or rocky can be made to answer the purpose, the chief considerations being the practical limitations on operation in the way of grades of main line tracks and sidings and the necessity of having level areas, or those which may be made so at not too great a cost, suitably located with reference to the other facilities of the terminal, and of sufficient extent for yard purposes.

One of the great handicaps under which the port of New York has been operating has been the lack of ample yard space on Manhattan Island for freight of local origin or destination. Cut off from railroad yards of any size by the Hudson and East Rivers, the overloaded piers of New York City proper have had to bear the additional burden of the local railroad freight which now surmounts these obstacles by lighter, ferry, or car float and is rehandled several times between the island and the line carrier, where otherwise it might be loaded directly into a railroad car bound for the classification yard or go through the simple operation of being trucked there over the city's streets. Very properly New York may be cited as an example of a location most difficult to provide with modern rail service, for suitably located yard areas are limited in number and extent and much excavation is involved in grading operations and that largely in rock.

On the other hand Chicago is a good example of a location which lends itself readily to railroad improvement. Grades are practically unknown, large flat unrestricted areas are available fairly near at hand for yards, and excavations are seldom required and then only in earth. Expensive foundations are about the only handicap, it being necessary to sink caissons upwards of 50 feet in depth to bed rock where heavy structures are involved.

The existence of large streams or other bodies of water in a terminal area have a decided bearing upon the layout of the rail facilities. If non-navigable, or if navigated but slightly and rail borne traffic predominates, the water areas effect the terminal layout only in so far as the expense of improvement is involved. But where the water borne commerce is of any magnitude substantial encroachments upon or obstructive crossings over the water areas are prohibited by state or Federal authority and as a result the layout of the terminal may be materially affected. The effect is marked still further where water borne commerce predominates for then the rail service is fashioned to meet the requirements of the operations by water. In adjusting these two conflicting interests in a terminal area the fact that the two are largely interdependent and can not thrive alone is often lost sight of. Occupancy of water frontage exclusively for railroad purposes or the imposition of unduly restrictive regulations with reference to the construction and operation of bridges does not operate to the ultimate benefit of either interest or contribute to the general welfare of the terminal.

Physical characteristics, therefore, influence the location of the terminal with reference to the sea or waterway, affect the kind of shore accomodations used, influence the extent of the anchorage area, and govern the location, layout and cost of construction of main lines, yards, freight-houses, and other auxiliaries.

Effect of Character of Traffic

In planning terminal developments, thought should be given to the charac-

teristics of the stream of commerce that is expected to be handled. Continuity of flow may be disturbed or interrupted by seasonal variations in shipments of one or more commodities. Grain shipments may occur any time during the navigation season on the Great Lakes but the average weekly shipments for late August and September are more than twice the average for the entire season. Rail carriers are faced with a similar situation and find the bulk of the grain movement concentrated in a few very busy weeks. It is necessary, therefore, to plan terminal facilities for the handling of grain so that the excess of supply over consumption may be stored at the terminals along the route of shipment and released more regularly and more in accordance with the availability of carriers. With grain there is a regular demand and an irregular supply, with the carriers and terminal facilities acting as equalizers. The reverse is true of coal, the demand for which fluctuates violently, whereas the supply is fairly regular.

Further complications are introduced when one means of transportation is unable to render all-year service. All American lake ports are closed to navigation during a part of the winter; some of the river ports are inaccessible during extremely dry seasons, although this handicap has been largely overcome in recent years. The seaport of Montreal, Que., Canada, is open for only a part of the year.

In order to provide for these various disturbances to the continuity of flow of commerce, storage facilities are necessary at one or more points along the route of travel. These facilities should be as near as possible to the locus of greatest fluctuation in order to equalize the load on the carrier. For grain movements by rail the nearer the elevators to the farms the better for the carriers; for movements by water, it is necessary that the ports be provided with adequate elevator service. For coal, the storage yards or sheds should be as near the consumer as possible.

Storage facilities for the purpose of equalizing differences of supply and demand are not all that are necessary to preserve continuity of flow. The journey of any commodity to ultimate consumer is composed of various stages. For exports, it is generally from truck to railroad, to vessel, to railroad, to truck. It is impossible to synchronize the movements of these different kinds of carriers. A railroad car is too valuable to justify its being held to be loaded directly from trucks as they arrive; nor is it economical to hold goods in trucks or cars until a sufficient supply has accumulated to complete the loading of a large carrier. As a result wherever a change in type of carrier is necessary, facilities suitable for the proper storage of the commodities handled must be provided.

Balanced Flow of Traffic

The function of all carriers is to move goods or passengers and their use for storage purposes is generally an economic blunder. Continuity of flow, therefore, may be facilitated by making provision for storage wherever there is a change in the type of carrier or where it is necessary to adjust the differences between supply and demand.

A balanced and diversified flow is another factor of importance in terminal planning. It is impossible to equalize the flow of a commodity, such as coal, throughout the season so as to give every departing vessel or car a full cargo. However, if other commodities are handled, the seasonal fluctuations of which do not coincide with these of coal, carriers will be able to remove a load regardless of the season.

It is of equal importance that the inbound and outbound traffic shall balance. Carriers are then assured of a load both ways and as a result can quote lower rates. Montreal is handicapped by the preponderance of its outgoing grain cargoes. As a result, great quantities of Canadian grain take the more expensive land route to New York City, where the load factor is not so one-sided, and foreign rates are resultingly lower.

The kind of freight passing through a port is an important consideration in planning for efficiency. If large quantities of any one commodity are to be handled, experience has shown that specialization of terminals, terminal equipment, and carriers results in economy that may not be achieved otherwise. It is well, therefore, to determine the kind as well as the quantity of freight to be handled in order to provide the best possible arrangement of facilities.

Freight may be classified as regards its source and destination. Local freight is that which originates in the vicinity of a terminal or is destined for consumption or manufacture there. In cities, such as London, New York or Chicago, the local freight is of so much importance to the welfare of the port and of such large proportions that it must be considered carefully in the terminal plans. The inhabitants of the terminal area are generally more interested in the efficient handling of the local freight than in the through freight. The efficient handling of this local freight insures support of terminal development.

Local freight may be of a general kind, such as that which passes through the down-town freight houses of a railroad or over the floor of a commercial transit shed. It also may be industrial, that is, originate at or be destined for industries situated on a siding or industrial canal. Through freight is that which originates elsewhere and is destined elsewhere, but must pass through the terminal. It may be stored for a time at the terminal, but as long as it is ultimately reshipped, it may be classed as through freight and treated as such.

Freight may be classified also as to the method of handling or kind of special treatment necessary, and for certain purposes more or less essential to terminal planning, it is well to do so. Following this plan, there are:

General .... Standarized package, miscellaneous package.
Bulk .... Coal, ore, grain, etc.
Perishables .... Fruits and vegetables.
Inflammables .... Oil, explosives.

Imports will require customs inspection; foodstuffs will require inspections to insure compliance with pure food laws; and immigrants, inspection by Public Health and Immigration officials. Freight coming under one or more of these classes will require special handling or treatment and should be planned for accordingly.

The Significance of Type of Carrier

The consideration of important factors in terminal planning should include an investigation of the types of carriers engaged in transporting goods for there are as many general types of carriers as there are highways. For railroads there are freight cars; for roadways, trucks; for inland waterways and canals, barges; and for lakes and ocean, vessels. This classification, however, is only general and wherever the shipment of large quantities of any one commodity has been involved, specialized carriers have resulted.

Under the general classification of railroad cars, open flat-cars are used for hauling heavy machinery and building stone; gondolas for coal; stock cars for cattle, horses, hogs, and sheep; refrigerator cars for meats and fruits; tank cars for petroleum; and box cars for general merchandise.

Trucks are not as highly specialized, but even under that category there are dump-trucks for building and other bulk materials; tank trucks for gasoline and oils; and merchandise trucks for general freight.

Barges have become largely standardized. For bulk cargo, open-top bulk carriers are used. If general cargo is to be carried, a deck-house, affording protection to the cargo as well as more carrying space for the lighter material, is fitted to the bulk carrier. The tanker is about the only departure from this modern standardized barge.

Carriers on the Great Lakes and the ocean might be arranged into two classes, those which specialize in the passenger business but which carry freight as an accommodation and to complete the cargo, and those exclusively engaged in the freight business. The

former arrive and depart on schedule, whereas the freighters stay in port until they are loaded. Schedules of passenger vessels are arranged so as to permit the complete discharge of the inbound cargo and the loading of as much outbound cargo as possible before departure. If the scheduled turn-around is short, very efficient terminal facilities are required.

The cargo space of the passenger vessels is adapted somewhat to the cargo to be expected at the ports of call, although little specialization is attempted, but if, for example, the passenger vessel regularly travels the route of the banana trade, special attention is given to refrigerating apparatus. Specialization, however, among freighters is more general. The specialized bulk carrier engaged in the ore, grain, and coal business on the Great Lakes is an efficient example of the type. There are also tankers for petroleum and its products; fruiters for the fruit trade; and the more or less standardized ocean freighter which can carry almost any cargo that is not fluid. The combination vessel which is intended to carry ore or coal in one direction and petroleum the other, is an interesting recent development.

As regards relative first cost, the following figures, although approximate because of the fluctuation of market conditions, will indicate the proper order:

Truck	\$500 to \$800	per ton cargo capacity
Vessel	75 to 125	per ton cargo capacity
Railroad car	40 to 60	per ton cargo capacity
Barge	20 to 35	per ton cargo capacity

These figures show the importance of keeping a truck or a vessel moving under load. This is largely true because the truck and vessel are self-propelled whereas the railroad car and barge are not. It is as important, however, to keep locomotives and towboats on the move as it is vessels and trucks. For purposes of comparison, it might be better to pro-rate the first costs of locomotives and towboats against those of cars and barges. Even if that is done, the same order results as follows:

Truck	\$500 to \$800	per cargo ton
Vessel	75 to 125	per cargo ton
Railroad car	55 to 75	per cargo ton
Barge	40 to 55	per cargo ton

The relative cost of haul per ton-mile is the next point to be considered. As in the case of first costs, figures should be used with caution. Furthermore, ton-mile costs are not always a criterion of economy, because, although they may favor one type of carrier, the difference in length of routes necessarily followed may more than offset the savings in unit costs:

Truck	\$0.05 to \$0.25	per ton-mile
Railroad car	0.005 to 0.01	per ton-mile
Vessel	0.001 to 0.005	per ton-mile
Barge	0.001 to 0.005	per ton-mile

The City Plan

It is believed proper to emphasize that the city plan not only should take into consideration the influence of regional and national tendencies and developments but also should give full weight to and make due allowance for the general features of the terminal plan. Conversely, the terminal plan should favor the city plan as far as possible and should take into account the inexorable demands of civic expansion, such as increased intramural transportation facilities, widened streets and boulevards, the modern tendency of promoting the health and contentment of the people by providing for wide open spaces, parks, playgrounds, and the like and by giving the whole civic structure a pleasing and aesthetic appearance.

In a good many instances the terminal plan may be made subordinate to the city plan without any material sacrifice in efficiency and at no great increase in cost to the terminal interests. In other cases the terminal plan is made to coordinate with a city plan by sacrifices on both sides. But even in cases where the terminal plan is made fundamental and the city plan is required to be formed about it—so to speak—the terminal interests should not take advantage of the favorable position occupied and unncessarily obstruct the execution of a reasonable city plan.

In one particular feature it is very easy for the terminal interests to make the realization of an adequate city plan very difficult; this has to do with the location of down town terminal facilities. These facilities, unless arranged and placed with due regard to civic expansion and vital city plans covering many years in the future, can do much harm to a community for they will obstruct normal and healthy growth and interfere with traffic circulation.

As far as possible terminal plans should be so prepared as to exclude from the down town commercial district the long haul freight carriers, i.e., railroads and vessels. An attempt must be made, therefore, to forecast the growth of the commercial district of a city so that the terminals of these carriers may be located properly with respect to it.

The tendency in the United States is for the commercial districts of most cities to expand vertically. This expansion takes place generally with little or no regard for the capacity of a city's streets or its intra-mural transportation and while efforts are made to curb this tendency by fixing height limits to buildings, eventually these restrictions give way to the pressure of expanding real estate values. So while the population of a commercial district may double in a certain time the area of that district may not increase very materially, certainly not in the same ratio.

While the area of a commercial district does not increase in proportion to the population the density of its street traffic grows at a greater rate so that in aiming to relieve congestion consideration must not be limited to the area actually occupied by the commercial structures, but should include the area within which the average density of street traffic exceeds certain safe limits.

The proper field for the railroad and for the waterway in the transportation business is in the long haul. The motor truck is specially adapted to the short haul and is rapidly becoming a valuable asset in large terminals. If the long haul carriers will eventually adopt the practice of making "store-door deliveries," and there is less argument now than before about the ultimate economy of such a procedure, it is believed that the proper solution will be to eliminate all down town freight houses, team tracks, and other rail freight facilities from the commercial zone. Furthermore, only such piers, wharves, and other shore accommodations for handling water borne freight which accompanies the passenger business should be permitted in this zone.

With such a concession on the part of the terminal interests the city planners will have no "bone to pick" with them. The complete terminal layout could then be made quite attractive from a local point of view and a city planner should have no difficulty in providing the thoroughfares and intra-mural transportation systems essential to free and rapid circulation of the population and its goods. Nor should a city planner with leanings towards an architectonic masterpiece despair for he would find no ugly warehouses, transit sheds or freight yards to contend with and he could proceed with a free hand toward the provision of down town parks, boulevards and other facilities of an aesthetic nature.

Water-Borne Commerce of the Chicago Region and Its Requirements

By E. O. GRIFFENHAGEN*, M. W. S. E.
Presented February 20, 1925

An analysis of the water-borne traffic in the Chicago area discloses the necessity of determining the future bridge policy of the city before adoption of a plan for the harbors. This paper gives a complete statement of the amount of business handled and the needs for development of each part of it. These questions should be settled now so that proper steps may be taken to safeguard the growth of water terminal facilities.—Editor.

Significance of Chicago's Location:

THE strategic position of the Chicago region with respect to waterways has had a very important influence on its development from the beginning of its history.

Fig. 1 is a map showing location of Chicago in relation to the principal transportation routes from the interior to the seaboard. Each solid line on this map represents a railroad running from the interior to the seaboard either double or single track. The dotted lines represent present water routes or single track. The dotted lines represent present water routes from the interior to the sea. Chicago's position on a large number of these routes is too evident to require explanation.

There are five particularly significant elements in the location of Chicago that have been, and will probably continue to be, large factors in its growth to commercial greatness. These are: (1) its position as the southwestern terminus of the Great Lakes Waterway, the point on that system nearest the center of the northern interior of the country; (2) its position as the southern terminus of the north and south water traffic in lumber and iron ore; (3) its position as a terminal of the Illinois Waterway on the connecting link between the two greatest inland waterway systems in the country—the Great Lakes system and the Mississippi system; (4) its location at a natural railroad center inevitable because the Lake Michigan barrier forces the lines from the northwest to converge in this region; and (5) its location near the eastern margin of the surplus agricultural producing region and the western margin of the important manufacturing area.

It will be noted that waterways and a potential water commerce is the prominent influence in three out of these five factors. In fact, the establishment of the settlement was the result of an appreciation by the earliest explorers of the importance of the position at the divide between the Great Lakes system and the Mississippi-to-Gulf system. The route of the present Drainage Canal was used regularly by early trappers and the Indians.

The Growth and Changing Character of the Chicago Water-Borne Commerce:

After 1822 when the Illinois and Michigan Canal was first seriously proposed, the village of Chicago gained in prestige and population due to the prospect of an inland waterway connecting the Lakes and the Mississippi River. By 1848, when the Illinois and Michigan Canal was completed, the City had already greatly increased in population, largely due to the Lake traffic and prospect of a greater traffic through the Canal. From 1848 up to about 1890, the lake, and in a decreasing measure the inland waterway, traffic were of material importance to the economic welfare of the community. Particularly, Chicago's dominating position in the lumber trade and the enormous proportions which that trade reached are accounted for by the City's ability to bring in lumber by water routes. Also, undoubtedly the existence of water transportation routes had a significant in-

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fluence in making Chicago the great rail transportation center which it is today. Although Chicago's strategic position aside from her advantages with respect to water commerce might have assured her development with respect to rail transportation, it is evident that the actual history of her growth as a rail terminal was greatly influenced by the existence of established waterway routes and commerce, notably the remarkable lumber commerce.

Today rail traffic entirely overshadows the water commerce. There are, however, certain important services which water transportation is rendering. The commerce of the steel industry is largely carried by lake vessels. It is by far the most important single branch of the lake commerce of today. There are, however, other items of lake commerce which are of distinct value and they will be commented on later.

Growth of Total Commerce

The earliest official records of the United States Engineers of tonnages carried by water to and from Chicago are those for the year 1890. It is difficult to get even fairly reliable figures for earlier years except as regards a few commodities. I will therefore attempt only a few general remarks as to the early commerce. The earliest record I have found of interlake commerce is that of a shipment of hides from Chicago in 1834. The first grain cargo eastbound, we are told, was in 1839. The commerce of the port developed rapidly from this time onward. Lumber, stone, grain, and other agricultural products have been important items from the first. Eastern coal entered as one of the significant items at an early date. By 1876, the total lake commerce of Chicago was probably about five and one-half million tons, and in 1882 it was a million or so tons greater. From about this time on, South Chicago began to gain tonnage, while the Port of Chicago proper began to suffer a reverse, due in the first instance largely to the decline of the lumber traffic. Also, the Illinois and Michigan Canal fell by the wayside as an avenue of transportation. Railways had demonstrated their greater efficiency and were rapidly reducing it to its present position of decay.

While the commerce of the Port of Chicago proper was declining, the total water commerce of the Chicago region continued to grow. The South Chicago tonnage had reached a total of nearly 2,000,000 tons as long ago as 1890. Indiana Harbor and Gary became important ports after 1910. By 1906, the total tonnage of the Chicago district was well over ten million. By 1916, the total tonnage was over sixteen million or eighteen million, depending upon which of two cources of information is to be accepted. Passing by the irregularities occasioned by the World War, we find that in 1923 the water commerce of the Chicago region was about twenty-two million tons, and in the year 1924 it is estimated that the total water commerce of the Chicago region amounted to about 20,000,000 tons.

These total figures, although illuminating, are quite unsatisfactory to anyone who really wishes to understand the water traffic problem. Various bulk commodities and the large group of so-called package freight or general cargo commodities are so strikingly different in essential characteristics and handling requirements that it is impossible to place reliance upon aggregate tonnage figures in arriving at any important conclusions as to the traffic or its needs.

History of the Important Classes of Lake Commerce

Let us review briefly the history of six important classes of lake commerce.

(1) First, as to package freight or the so-called general cargo, we find that this commerce is now of great importance at the Port of Chicago proper and is of no importance at all at South Chicago, Indiana Harbor, or Gary—the other three ports of the Chicago region. Although statistics as to package freight are very unreliable, it is known that Lake Michigan and interlake boats of the general cargo type have operated for many years, and that even as long ago as 1890, the commerce was very heavy. In fact, the figures indicate a

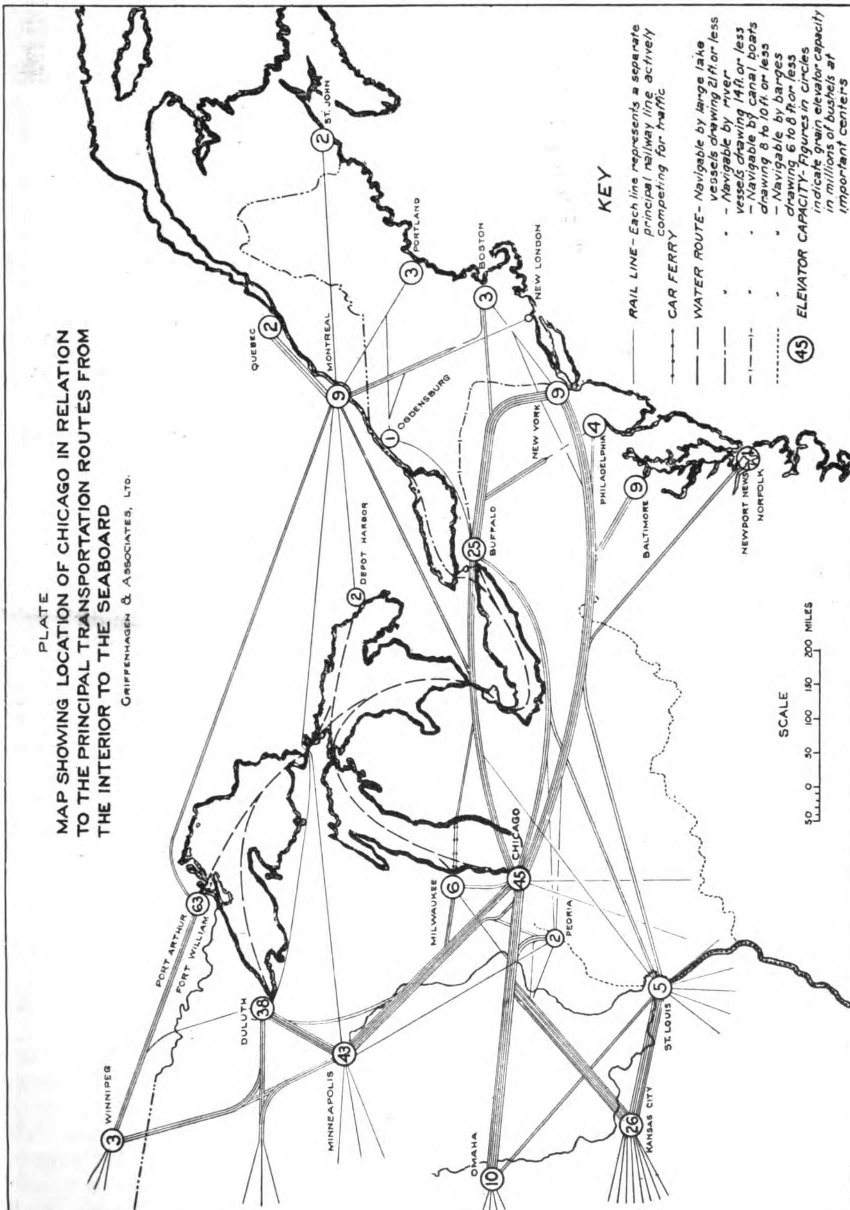

FIG. 1. MAP SHOWING THE PRINCIPAL TRANSPORTATION ROUTES FROM THE INTERIOR TO THE SEABORD.

miscellaneous or general cargo tonnage in 1890 that was greater than that today, but it would not be safe to place much reliance on the statistics for early years. Just before the World War, the package freight lake commerce was very heavy, possibly amounting to over twice the present commerce, that is, to nearly two million tons per annum. Also, if we may accept the statistics of the period from 1901 to 1908, the commerce during a few of these years was even greater than the 1913 commerce. The package freight commerce today is about 800,000 tons a year, exclusive of the intraport movements mentioned later.

Package freight and miscellaneous lake commerce of the Chicago district was reported as follows:

1890	900,000 tons
1913	1,800,000 tons
1923	800,000 tons

We can rely on the figures as correctly reflecting the existence of a very heavy commerce before the War. The 1923 figure does not conform exactly to the United States Engineers' report, but is that built up by the Chicago River Bridge Survey.

(2) The great lumber traffic which caused the Chicago River to be literally crowded with sailing boats and steamers during the '70s, '80s and '90s, rose to the astounding total of 3,970,000 tons in 1882. Its decline was not great up to 1892, but from then on it lost ground steadily and with remarkable rapidity. By 1910, the statistics show a total of only 700,000 tons, and the water commerce in lumber today is about 50,000 tons a year.

Fig. 2 is a chart showing receipts of lumber by lake compared with total receipts at Chicago. Because the curves do not go back to the days of the greatest lake traffic in lumber this plate shows principally the decline in lake receipts. The line for lake traffic drops almost to zero. The spread between the two lines shows the growth of the rail traffic. The broken line is total receipts and the solid line the receipts by water.

(3) Another declining traffic in bulk commodities is the hard coal traffic. This movement from Lake Erie ports was heavy during the '80s and '90s and for many years since then. It amounted to over a million tons as recently as 1913, although it had begun to decline before that date. Its highest year was 1892 when the records show 1,460,000 tons. In 1923 the hard coal traffic was less than 600,000 tons, including 200,000 tons interchange coal handled at South Chicago.

Fig. 3 is a chart showing lake receipts of anthracite coal at Chicago and South Chicago. It should be noted that almost 2,000,000 tons of hard coal reach Chicago by the all-rail routes. This chart shows only the lake traffic and indicates the trend downward. This is due to decreased consumption and to other factors including the stretching out of the City so that rail yards are nearer to destinations than are the coal docks around Goose Island and elsewhere.

(4) The lake grain traffic is, as has been mentioned, one of very early origin. It has always been of very irregular volume, one year being high and the next year possibly very low. The year 1898 seems to be the greatest year of this traffic, the records showing 3,675,000 tons, but the unusual conditions prevailing in 1921 resulted in a very heavy total for that year also—almost as great as 1898. While the original grain traffic was handled through Chicago River elevators, the present traffic is largely taken care of at South Chicago.

A chart showing Chicago lake shipments of grain and a comparison of lake shipments and elevator capacity is given in Fig. 4.

Variations in shipments from year to year are due primarily to the variations in exports from the United States. Recently the lake movements have tended to increase somewhat at the expense of rail movements due to the development of the Montreal route though the percentage of lake shipments was higher during the '90s. (42 to 72% in the '90s; recently 19 to 59%.)

Fig. 5 is a map showing destinations

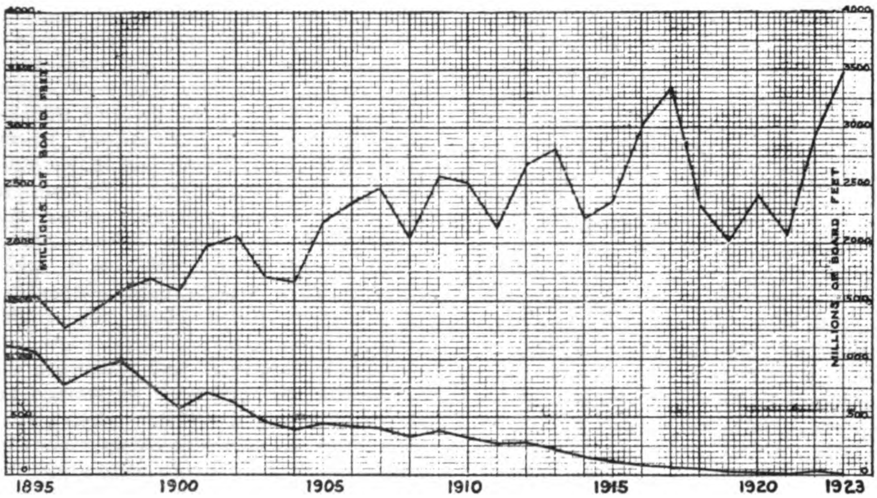

FIG. 2. LUMBER SHIPMENTS BY WATER HAVE PRACTICALLY CEASED.

of lake shipments of grain from Chicago, annual average, 1914-1923.

This shows the grain water routes eastbound and the average importance of each during the period 1914-1923.

(5) The sand and gravel traffic is a peculiar, more or less local branch of the lake traffic which has become very important. It has grown more or less steadily. Before the War, there were two or three boats in this service, and today there are seven, all of which are self-unloaders. If all of these operate constantly they will bring nearly 2,000,000 tons of material to Chicago. In 1923 they carried about 600,000 tons of lake sand and gravel principally to yards along the Chicago River.

(6) The only remaining items of lake commerce of importance are those of the steel industry, including ore, limestone, and semi-bituminous coal. This commerce has grown to enormous proportions. Ore and limestone come from northern ports, and semi-bituminous coal from West Virginia via Lake Erie ports. It may be mentioned, incidentally, that the United States Steel Corporation does not bring its coal by lake, though the costs via the lake route are less than those by rail. The total tonnage for the steel industry in 1923 was over 18,000,000.

The 1923 South Chicago tonnage of the steel industry was about 10,000,000. Gary comes next with about 5,000,000 tons. Indiana Harbor comes third with over 3,000,000 tons. The Chicago River is not now one of the ports of this industry and never has had large tonnages of ore. South Chicago was important before 1890; the other two ports developed much more recently, principally since 1912.

History of Inland Waterway Commerce

So much for the history of the more important phases of the lake commerce. I am unable to furnish statistics which would be of any particular value, as to the traffic on the Illinois and Michigan Canal. Today the tonnages are practically nil although the Canal is operating at least a considerable part of the time. It now connects with the Drainage Canal, and the historic movements of stone from quarries at Lemont are continued on the Drainage Canal. Also, considerable quantities of stone come to Chicago by barge from the spoil banks of the Draininge Canal. It is estimated that the stone brought in via the Canal amounted to about 700,000 tons in 1923. There is one other canal movement to Chicago—that of gasoline and oil.

History of Intraport Commerce

The remaining type of water commerce is the intraport traffic on the Chicago River. It is rather important. It has developed gradually over a long period, and includes barge and lighter movements of grain, package freight, excavated material and waste, and car ferry movements of miscellaneous freight. As regards tonnage and value, the package freight lighterage is far more important than the barge movements of bulk commodities. The car ferry movements began in 1913 and have increased to such an extent that it seems entirely possible that they may become the most important intraport movements in the future. The total tonnage of all classes of water-borne freight within the port of Chicago in 1923 was over 800,000.

Development of Types of Vessels

Before summarizing the figures as to the present traffic, it may be well to add a few comments as to two other aspects of the history of the water-borne commerce. First, as to the types of vessels employed, we may go back to the very earliest days when canoes still had a place as traffic carriers, and follow the progress of the development of the craft through the early days when very small sailing vessels were used, through the periods of growth in size of sailing vessels up to the peak of the lumber trade in the '80s, and to the periods of development of lake steamers beginning back in the days of this large lumber trade. A few wooden steamers typical of those introduced in the lumber trade are still in service. The ones now found vary in deadweight cargo carrying capacity from about 500 to 1200 tons (440 to 789 gross). We still have in service also, Lake Michigan passenger boats, the hulls of which were built of wood at a comparatively early date. The bulk freighters and the boats operating in the interlake package freight trade are larger. The present package freighters vary in size up to about 5,000 tons deadweight cargo capacity. They are of steel. The bulk freighters calling at points in the Chicago River are generally fairly large and have a deadweight cargo capacity up to 7,000 tons or even a little more. The bulk freighters calling at South Chicago include many that are typical of the most recent developments of Great Lake freighters and run as high as 12,000 tons deadweight cargo capacity. All of the more modern types of boats are of steel.

Diesel-drive craft have been introduced to a very limited degree. The Steel Corporation has recently acquired two

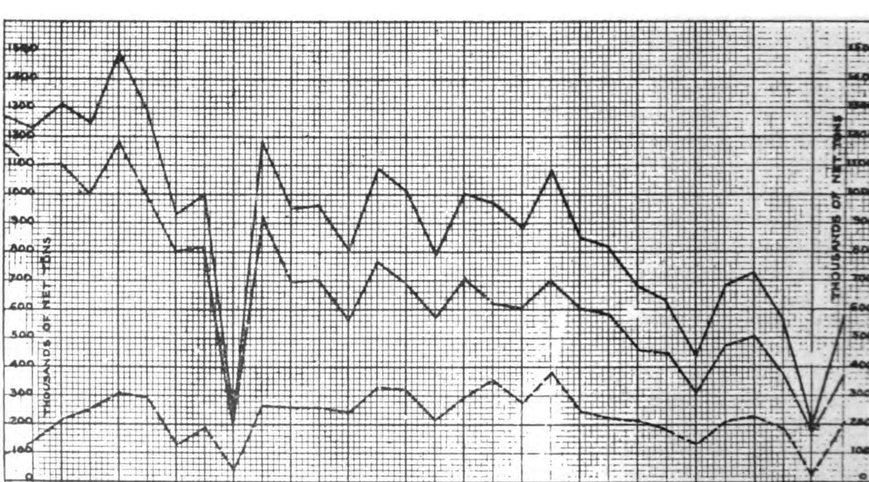

FIG. 3. HARD COAL RECEIPTS BY WATER. THE SOLID LINE IS TOTAL RECEIPTS. THE BROKEN LINE SHOWS THE PART COMING TO CHICAGO AND THE DOTTED LINE RECEIPTS AT SOUTH CHICAGO.

Diesel-drive boats for general cargo use. The most recently constructed lake sand boat is also Diesel-drive. A line operating from Duluth to New York City through the New York State Barge Canal is taking advantage of the small space occupied by Diesel engines to permit them to secure fairly large craft that will pass under the fixed bridges over the New York canals. Thus, from Duluth to New York, there is an all-water route for grain and package freight which does not involve any re-handling of the commodities en route. It is possible that a similar line might be successful if operated from Chicago to New York. Also, it is not unlikely that Diesel engines may prove their utility in many lines of traffic on the Great Lakes and inland waterways.

History of Inland Waterway and Port Development

As to the inland waterway developments affecting Chicago, it is hardly necessary to add more than a few incidental comments. The history and early importance of the Illinois and Michigan Canal has been mentioned. It should be noted that the construction of the present Drainage Canal offers a ship channel for thirty-two miles beyond Chicago. It was originally hoped that lake boats would take advantage of this waterway and that the district along the Canal would become an important industrial belt. As has already been mentioned, no such development has occurred. Agitation for the extension of the ship canal farther south has been more or less continuous. Engineers who have studied the problem have advocated less radical proposals, and, as is well known to this group, an eight or nine foot channel to connect the Drainage Canal with the Mississippi River system is now being built. It should be pointed out that the failure of the Illinois and Michigan Canal is no indication that the modern Illinois Waterway will not succeed. The purpose of the larger waterway is to make possible the use of economical types of craft, and although there are serious problems to be solved before the Illinois Waterway can hope to take an important place as an avenue of transportation, it will undoubtedly offer facilities of material importance to the Chicago Region.

With the decline in Lake commerce at Chicago, the agitation for remedial measures became very active. At the height of the use of the Chicago River, slips were built by private capital, terminals were provided, and even some improvements in the channel of the river were made without public expenditure. As the commerce began to fall away, however, it was insisted that the public authorities should take action to improve the river channel to take care of the larger modern boats, and should provide water terminals. In the meantime, at South Chicago, the steel industry was having no difficulty in taking care of its own terminal needs. Also, the coal industry and the grain industry were constructing their terminal facilities.

The first formal expression of the agitation for radical changes in policy as to public assistance for water terminals came in 1909 when the Harbor Commission of that year issued a report which is essentially a compendium of a great many proposals for public assistance to the declining water traffic. The first concrete act of very great importance was the erection of the Municipal Pier in 1916. The failure of this Pier immediately to cause a large commerce to spring into existence dampened the ardor of many more or less thoughtless waterway enthusiasts. Since that time, no large expenditures have been made for waterway terminals, but the City has from time to time created Harbor Districts by ordinance, and to a limited extent, at least, has kept in mind the fact that city planning should be related to the declarations as to the use to be made of these Harbor Districts.

Incidentally, the river channel has been improved greatly. The current in the river induced by the diversion of water necessary to dispose of the Chicago sewage was so great a handicap to river navigation at bends and sharp elbows in the River that the

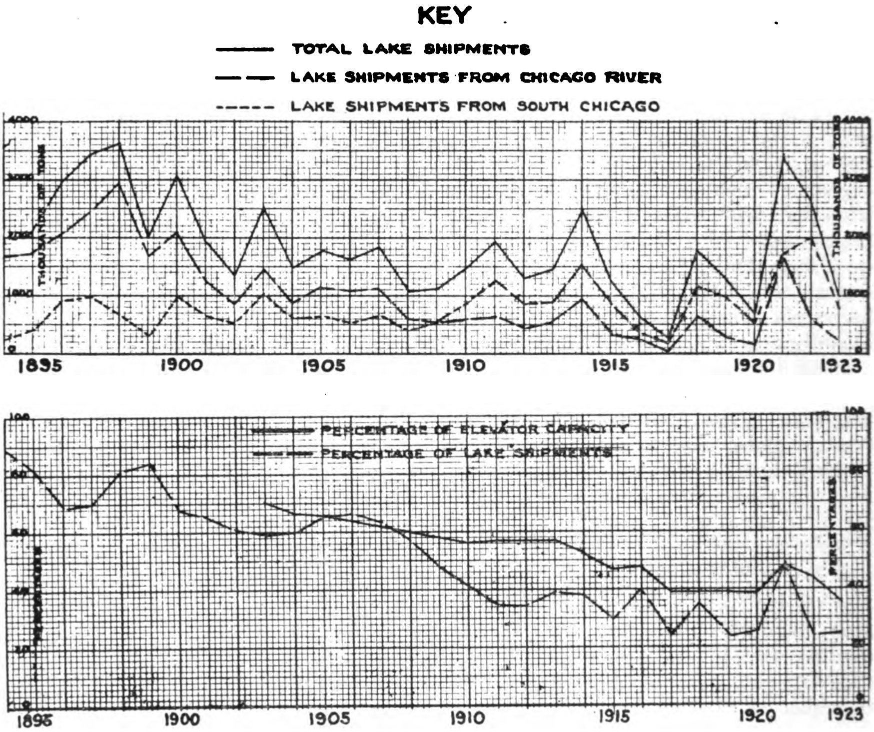

FIG. 4. COMPARISON OF GRAIN SHIPMENTS FROM CHICAGO RIVER AND SOUTH CHICAGO.

Sanitary District found it necessary to spend large sums straightening the river. Also, the development of bascule bridges to replace most of the old center-pier swing bridges is another important improvement of the river channel. But notwithstanding all of these improvements, the channel of the Chicago River is not nearly so satisfactory as the Calumet River channel, and the largest bulk freighters cannot enter the Chicago River. As a matter of fact, this is probably not a handicap of any very great significance. With the straightening program that has taken place and the removal of nearly all center piers, the River has just barely met the needs. The decline in the commerce of the Chicago River has been caused by other influences, notably the improvement and increased efficiency of rail transportation and the transfer of the important lumbering operations away from the lake shores.

PRESENT VOLUME OF WATER-BORNE COMMERCE

Total Tonnages and Values of the Present Water Traffic

The total water commerce of the Chicago region should be considered as of three parts—first, the lake commerce; second, the inland waterway commerce; and third, the intraport commerce. The foregoing historical remarks followed this same division. We may summarize them insofar as they pertain to the present water-borne commerce and secure a complete picture of the whole by considering two tables (Nos. 1 and 2) the first of which gives tonnages, and the second estimated values of each of the three branches of commerce and for each of fourteen classes of commodities. The commodities are arranged in order of volume and value respectively in the two tables.

Considering first only the lake traffic,

it will be noted that the commodities constituting the water commerce of the steel industry take the lead so far as tonnage is concerned. In fact, out of a total water-borne commerce of 22,560,000 tons, over 18,000,000 tons is accounted for by this movement. So far as the lake traffic alone is concerned, grain is the next item as regards tonnage, and the other large items include package freight, oil and gasoline, sand and gravel, and hard coal. The total value of the lake commerce is estimated at $296,000,000, and of this total about $66,000,000 is accounted for by the steel industry. The package freight heads the list of items of commerce on a value basis, the $154,600,000 being 53 per cent of the value of the total commerce.

The only items of inland waterway or Drainage Canal commerce are stone, and oil and gasoline, the former being by far the most important when judged by tonnage, but the latter being the most valuable.

Of the intraport movements, waste and garbage is the greatest in tonnage, but is given no value. Package freight comes second as regards tonnage and first as regards value. The car ferry movements come third in tonnage and second in value. The rest of the intraport movements are of small importance, though it is surprising to see how much money is involved in some of them as, for example, the comparatively insignificant movement of tar and the movements of grain between elevators.

The value of the entire water-borne commerce, including the lake commerce, the Drainage Canal commerce, and the intraport movements of all kinds, runs to the astounding figure of $377,000,000. This, of course, includes the commerce of the Port of Chicago, that of the Port of South Chicago, and that of Indiana Harbor and Gary. Of this total, however, well over $200,000,000 represents the value of the commerce of the Port of Chicago, and almost $90,000,000 represents the value of the commerce on the Chicago River exclusive of the river mouth. The commerce of the steel industry as mentioned above involves about $66,000,000.

Analysis of Present Water Traffic

A few comments as to each of the major groups making up the water-borne commerce of Chicago, particularly with respect to their origins or destinations, will help to interpret their tendencies and requirements.

The iron ore comes from Duluth, Superior, Escanaba, and other Lake Superior ports. The boats which carry this traffic may return light or may carry grain from Chicago to Georgian Bay or eastern points.

The limestone for the steel industry comes from the upper shore of the main Michigan peninsula, the town called Calcite being an important origin.

TABLE NO. 1

WATER-BORNE COMMERCE OF THE CHICAGO DISTRICT, 1923

Thousands of Tons

Commodities	Lake Commerce	Inland Waterway Commerce	Intraport Commerce	Totals
1. Iron Ore	13,324	......	......	13,324
2. Limestone for the steel industry	2,904	......	......	2,904
3. Soft Coal	2,515	......	4	2,519
4. Sand, Gravel and Stone	590	675	19	1,284
5. Package Freight and Miscellaneous	789	......	280	1,069
6. Grain	982	......	43	1,025
7. Oil and Gasoline	748	59	......	807
8. Hard Coal	583	......	......	583
9. Waste and Garbage	......	......	341	341
10. Car Ferry Miscellaneous	......	......	100	100
11. Salt	75	......	......	75
12. Lumber	45	......	14	59
13. Tar	......	......	20	20
14. Flaxseed	5	......	......	5
Totals	22,560	734	821	24,115

Soft coal for the steel industry, that is the semi-bituminous coal, originates in the Pocahontas, New River, and other West Virginia and neighboring regions. It moves by rail to Sandusky or some other Lake Erie port and thence by boat to Chicago. As has already been noted, a great deal of it comes by the all-rail route, notably that for the United States Steel Corporation. A very small quantity of soft coal is brought to Chicago for bunkering boats; the latter is not semi-bituminous.

The local character of the sand and gravel business has already been noted. Also, it has been explained that *crushed and quarry stone originates* at points along the Drainage Canal.

For years grain was the only outbound bulk commodity. Today it is the only outbound bulk commodity carried by ordinary bulk freighters. The tonnage varies greatly from year to year. The destinations which are typical include primarily the Georgian Bay ports of Canadian railways, Buffalo, and Montreal. A considerable quantity of the grain going to Montreal is transferred from the larger lake boats to small lake boats at the mouth of the Welland Canal, that is at Port Colborne.

The only other present outbound bulk commodity or class of commodities is oil and gasoline shipped from the Standard Oil refineries at Whiting (immediately north of Indiana Harbor). This traffic is carried in special tank boats to various lake ports. The comparatively much smaller Drainage Canal movement originates at a refinery of the Texas Company at Lockport, the destinations being at two points on the Chicago River, one on the South Fork of the South Branch, and the other on the North Branch, both being stations of the Texas Company.

The hard coal movement originates in the anthracite coal region of Pennsylvania, and a very large part of the coal comes by the all-rail route in box cars that move eastward with grain. The hard coal which comes by lake is carried by the anthracite coal railroads to Buffalo or other Lake Erie ports where it is received by lake ships. The hard coal for Chicago consumption is unloaded at docks along the Chicago River, though there is quite a quantity of hard coal handled at South Chicago for reshipment by rail to neighboring points.

The salt comes from mines of the Morton Salt Company at Ludington, Michigan, principally. It is all unloaded at the refinery of the Morton Salt Company just south of the mouth of the Chicago River.

The lumber originates at comparatively small mills on the ports of upper Lake Michigan and Lake Superior. Some of it originates on islands.

TABLE NO. 2
WATER-BORNE COMMERCE OF THE CHICAGO DISTRICT, 1923

Commodites	Assumed Values Per Ton	Values: Lake Commerce	Values: Inland Waterways Commerce	Values: Intraport Commerce	Values: Totals
1. Package Freight and Misc.	$200.00	$157,800,000		$56,000,000	$213,800,000
2. Iron Ore	3.87	51,600,000			51,600,000
3. Grain	35.00	34,300,000		1,500,000	35,800,000
4. Oil and Gasoline	39.00	29,200,000	2,300,000		31,500,000
5. Car Ferry Miscellaneous	200.00			20,000,000	20,000,000
6. Soft Coal	4.40	11,080,000			11,080,000
7. Hard Coal	10.00	5,830,000			5,830,000
8. Limestone for Steel Industry	1.10	3,200,000			3,200,000
9. Sand, Gravel, and Stone	1.50	885,000	1,012,000	28,000	1,925,000
10. Lumber	30.00	1,350,000		435,000	1,785,000
11. Salt	9.00	675,000			675,000
12. Tar	10.00			200,000	200,000
13. Flaxseed	35.00	175,000			175,000
14. Waste and Garbage	Zero			Zero	Zero
Totals		$296,095,000	$3,312,000	$78,163,000	$377,570,000

The interlake package freight movements are carried by three lines. The Great Lakes Transit Corporation operates between various lake ports, the eastern terminal being Buffalo. Practically all of its Chicago freight is carried to or brought from Buffalo. The Rutland Railroad at Ogdensburg, New York, on the St. Lawrence River. Its boats are comparatively small, this being necessary in order that they may pass through the present Welland Canal. The Canada Atlantic Transit Company is a part of the Grand Trunk Railway System, and its boats operate to and from the ports of the Grand Trunk Railway in Georgian Bay. All of these interlake package freight lines carry considerable quantities of sugar, coffee, textiles, and other eastern and import products on the west-bound trip. Eastbound they carry a great deal of flour and other mill stuffs which do not originate at Chicago but are picked up at the railway docks in the Chicago River. Two of these lines fill their holds with grain on the east-bound trip. Some of the boats of the Great Lakes Company have carried grain, but this is not the general practice. Under present conditions, the load factors of the interlake boats are likely to be somewhat too low to make the business really profitable.

A special branch of the interlake commerce is the automobile traffic carried by boats which specialize in this trade and a number of which carry no other freight. The automobiles come from Detroit and nearby cities and are all unloaded at the Municipal Pier. There are now two boat companies in this trade.

The Lake Michigan package freight and passenger lines operate between Chicago and a considerable number of Lake Michigan points. The lines running to Wisconsin points, notably Milwaukee and Racine, carry quantities of manufactured goods in either direction, including machinery and other manufactured iron in various forms. The boats operating to and from points in the State of Michigan carry manufactured goods to some extent and large quantities of summer resort supplies. Also, the latter boats carry relatively great quantities of produce destined for what has been the South Water Street market. All of these boats carry some automobiles, including primarily the tonnage of tourist cars moving with passengers.

Each of the above three classes of package freight traffic is so distinct from the others that we have here a very clear illustration of the fact that even where a term that is in many respects definite is used, for example, the term package freight, an understanding of even the most fundamental facts as to the traffic requires that the movement be analyzed with care, and that the origins and destinations and the peculiarities of the transportation services be studied. Among the striking differences between the interlake commerce and the local Lake Michigan traffic, for example, is the fact that while the Lake Michigan traffic is made up of L. C. L. movements, the interlake traffic is almost exclusively a carload movement. Also, although both of these traffics are carried on published tariffs, the interlake traffic relies principally upon the savings which may be secured by using their routes, while the Lake Michigan traffic generally secures its popularity by speed and service alone; that is to say the rates are no lower than rail rates.

The above completes the comments as to lake traffic and includes mention of the inland waterway movements of stone and oil and gasoline. A word or two may now be said concerning the intraport movements. The package freight lighterage is that of the Merchants Lighterage Company and that of the Hibbard, Spencer & Bartlett Company which has a boat going back and forth between its two buildings in the Main Branch of the River. The Merchants Lighterage business is that of a public carrier operating primarily between shippers' places of business and the railway stations. The grain movements are those of the Armour Grain Company. This company has occasion to transfer grain from one elevator to

another and does so by boat. The garbage movements are a city enterprise, the movement being to the reduction works on the South Fork of the South Branch, from the two loading stations on the North Branch. A comparatively small movement is that of water gas tar from power plants on the River to the Barrett Company on the Drainage Canal but inside the City limits. Some lumber and some stone are delivered by barge from yards to places where construction work is going on. In connection with the construction and miscellaneous work, there are many movements of contractors' floating equipment, notably derricks, pile drivers, and mud and deck scows. Occasionally, dredges are operated in the River, and movements of dredges are not uncommon because there are the yards of two contractors located up the River, and the dredges come to these for repairs and to tie up. One of the bunkering companies has a boat that is used to bunker package freight boats, so this is one of the types of craft to be seen occasionally. Also, there are a few waste scows such as the one which is frequently to be seen tied up at the Kirk Soap factory building next to Michigan Avenue. Aside from the tugs, the occasional yachts and houseboats, the fire boats, various launches, and a couple of compressor scows owned by the city, this gives a pretty complete accounting for the various craft that are found within the port.

Estimates of the Future Volume of Water-Borne Commerce

The history of Chicago's water commerce has been so varied and irregular that it is impossible to find a very sound basis for estimates of the future commerce. It is evident that there is no justification for attempting to project the curve of the past total water-borne commerce into the future. Each item of the water-borne commerce is affected by conditions peculiar to itself. There is no reason to expect that the water-borne commerce will increase in proportion to the increase in rail commerce. It is known also that a growth in population and business can not be expected to cause a proportionate growth in the water-borne commerce of the region.

On the other hand, it is always possible for fundamental changes in relative costs to occur, and the very great preponderance of rail commerce makes it possible that the diversion of only a very small percentage of the rail traffic to water routes would mean enormous percentage increases in certain branches. of the water commerce.

Under these circumstances, it is desirable that the community plan its future development with full recognition of the possibility of a large future water-borne traffic; while, on the other hand, expenditures which would be justified only by the existence of a heavy traffic should not be made until there is definite proof that such traffic will become a reality.

The most important future development which may affect the volume of the Chicago water-borne commerce is the completion of the proposed St. Lawrence Ship Channel to afford an all-water route for vessels of modern dimensions direct from Chicago to the Atlantic sea coast and to foreign ports. The effect of this improvement is difficult to judge because no comparable conditions are to be found in other parts of the world, and there are very few definite facts available as to exactly what the characteristics of the St. Lawrence waterway traffic will be. We do not know the sizes of the channels which will be completed between Chicago and the seaboard. The channel conditions are uncertain as to Chicago, particularly because the only definite plans which have been made so far are for the improvement of the channels inland as far as Toledo. We cannot foresee the future exports of grain or of other commodities. The commodities which would be handled and the probable tonnages include those which vary most radically, namely export grains as well as other exports and imports.

It is impossible in this paper to go into the many questions raised by a study of the prospects for future Chicago commerce through the St. Law-

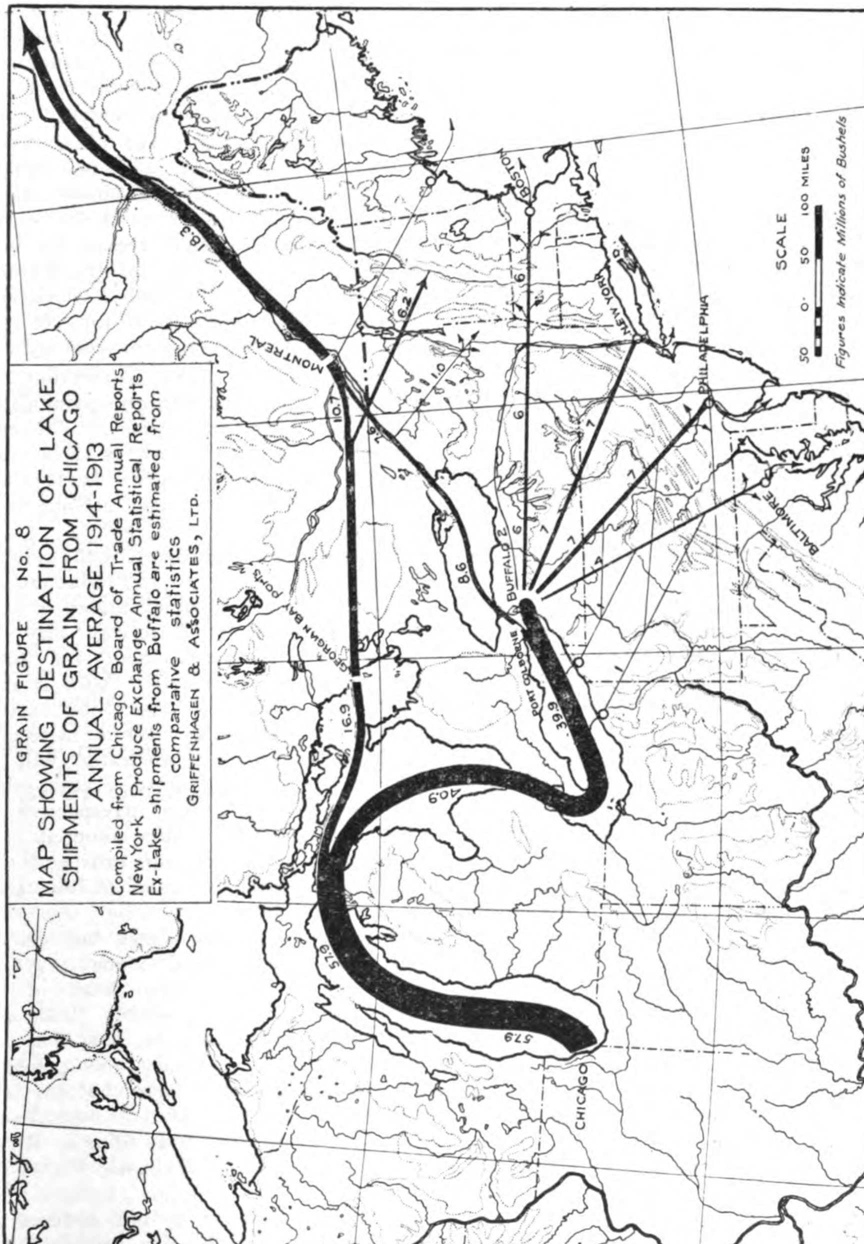

FIG. 5. FLOW CHART SHOWING DESTINATION OF GRAIN FROM CHICAGO BY WATER.

rence Waterway. It may be said very briefly, however, that after an extended study of this subject, it was decided that the more extreme estimates of the probable water-borne commerce of Chicago which were accounted for by assuming millions of tons carried through the St. Lawrence Waterway were hardly justified by the fragmentary data available. It seems much more likely that not more than one or two million tons of cargo will be Chicago's share of the St. Lawrence Channel general cargo traffic. In addition, the St. Lawrence Channel will mean some increase in the grain traffic, due to the lower all-water route rates.

There does not seem to be any question but that the St. Lawrence Channel will be constructed sooner or later.

Another proposed waterway which will affect the water-borne commerce of Chicago is the Illinois Waterway. The principal commodity which it is expected will be carried by this route is soft coal from Southern Illinois. It cannot be definitely proved that the saving in coal transportation costs will be sufficient to result in a very large coal movement, but it is possible that the total traffic will run into the millions of tons. Another commodity which may be brought into Chicago in large quantities via the Illinois Waterway is sand and gravel. The tonnage of this commodity or class of commodities might easily run into the millions. The Illinois Waterway package freight movements probably will not be very heavy, though some enthusiasts would estimate these as many hundreds of thousands or possibly even millions of tons. The Illinois Waterway might carry some lumber and a very little grain. There is every reason to believe that the extreme estimates of lumber tonnage, and particularly those of grain tonnage, are wholly without foundation.

We may summarize such conclusions as it seems possible to make with respect to the probable future Lake commerce in each class of commodities as follows:

All of the branches of the commerce of the steel industry may be expected to continue to grow, though it should be mentioned that the character of this commerce is such that the community will probably have little responsibility for providing any types of facilities for it. This commerce includes iron ore, limestone, and semi-bituminous coal.

It is possible that large quantities of semi-bituminous coal will be shipped to a point on the Drainage Canal through the Chicago River if the bridges over the Chicago River remain movable. This point is the plant of the Chicago By-Products Coke Company, which consumes over a half-million tons of coal a year and now brings the coal by rail.

The hard coal traffic is certainly declining and may be entirely extinguished within the next fifty years. The consumption of hard coal is less each decade, and the difficulties in handling smaller quantities by water become more marked.

Grain shipments probably will gradually become less, due to a reduction in exports from the United States, though the St. Lawrence Waterway may increase the lake movement for some years after it is opened. Also, it may be a very long time before the exports of the United States decline materially and permanently. The traffic will be handled at South Chicago rather than on the Chicago River irrespective of the Chicago bridge policy adopted.

There is little or no prospect that there will be any revival of the Lake receipts of lumber.

The present very large movements of sand, gravel, and stone may be increased further. The total of all water movements probably will run into the millions of tons, but it is not possible to say whether the principal source will be the lake bottom and points across the Lake, or the banks of the Desplaines and Illinois Rivers after the Illinois Waterway is completed.

Interlake package freight movements may increase greatly, due principally to the improvement of the all-water channel to foreign points. It is believed that two million tons, however, is a

very high figure to predict for the traffic even under the most favorable future conditions which seem to be possible.

The Lake Michigan freight movements and passenger movements of the Lake Michigan lines probably will steadily increase for a number of years. The rate of increase might be such as to mean the doubling of the traffic over half a century or so.

If the lake commerce of the Chicago River is interfered with by fixing of bridges, it is to be expected that the hard coal traffic and the very small lumber traffic will cease to exist, though the tonnages of no other branches of the existing lake commerce should be affected.

The Illinois Waterway should be important as regards the transportation of soft coal, sand and gravel, and relatively smaller quantities of lumber.

The intraport movements of the future will probably increase in volume more or less steadily, and not very abruptly. The only intraport movement which might run to many times the present tonnage is the car ferry movement, and there is perhaps less likelihood for this to develop to enormous proportions than may appear to those who study the matter casually.

Survey of Existing Water Terminal Facilities

It is possible to describe the water terminal facilities of the entire Chicago Region, including South Chicago and the other two ports, in general terms, but figures as to frontages and values of buildings and equipment are not available except for the Chicago River. A complete inventory of the use of all land and structures erected to care for various operations connected with traffic on the Chicago River has been made in connection with the Chicago River Bridge Survey.

Terminal facilities should be considered according to their kind, use, and adaptability. Facilities for coal, for example, have little in common with those for any other bulk commodity or for package freight.

At Chicago and on the Great Lakes generally, package freight traffic is handled without special unloading equipment. Lake boats are all of the side-port variety, the cargo being taken aboard and removed on ordinary hand trucks. The typical stevedoring rate for miscellaneous package freight at Chicago is about 70 cents per ton. The boat companies all have their home docks in the river mouth, or not far from the mouth of the river and at the Municipal Pier. The interlake lines, however, unload small quantities of freight at private warehouses and industries along the interior river, and carry very considerable quantities to and from railroad docks in the South Branch. The typical boat company dock is a one-story wooden structure having a comparatively narrow open platform along the bulkhead. The Municipal Pier is the only expensive wharf built solely for water commerce, and the upper story of this structure is essentially superfluous.

The terminal facilities for grain are well known. They are simply the grain elevators. The older elevators are similar to the Armour Elevator at the Lake Front and to the larger Armour Elevators on Goose Island. There is one elevator of modern type on the Chicago River, and there are several of the most modern and efficient types in the Calumet District. All of these elevators are equipped for handling both rail and water traffic, and the receipts are practically all by rail. The shipments by rail exceed the shipments by water.

The coal docks are equipped with costly unloading machinery, and with sheds in the case of hard coal docks. The rapid unloading equipment is necessary to permit the lake boats to discharge their cargoes and get away within a short period. The most modern and rapid equipment is that at South Chicago at the large and important soft coal docks notably those of the By-Products Coke Corporation at 112th Street. The hard coal docks on the Chicago River are of comparatively old type but have capacity and speed great enough to secure fairly advan-

tageous lake rates. It is figured that the cost of unloading at such a dock as that of the Hanna Coal and Dock Company on the North Branch of the Chicago River is likely to run to about a half-dollar a ton.

In some cases no terminal facilities are provided for the sand and gravel traffic other than the land upon which the material is unloaded. A few of the yards have concrete roadways and loading hoppers. They all use some kind of portable equipment for loading wagons. The yards which handle crushed stone brought in by barge are the only ones that require unloading equipment for the material received by water, and the unloading of the barges need not be particularly rapid, so the ordinary small portable cranes serve the purpose. The only large investment in the sand and gravel business aside from the self-unloading lake boats is that at the screening and elevating plants and that employed in removing the material from the ground.

The lumber traffic does not involve the use of any special terminal facilities. The boats unload at such lumber yards as still continue the practice of bringing a part of their lumber by water, or at the mills where the lumber is consumed in making boxes or flooring.

The oil and gasoline traffic is rather important as judged by the value of the commodity, but it is similar to the lumber traffic in requiring no particular facilities except the ordinary arrangements for handling gasoline at refineries and wholesale stations.

REQUIREMENTS OF THE PROBABLE WATER-BORNE COMMERCE OF THE FUTURE

Effect of Fixing Bridges

There are no revolutionary changes to be expected in the water-borne commerce of Chicago during the next ten years unless within that period the City adopts a fixed bridge policy and thus closes the Chicago River to lake vessels. One effect of the adoption of such a policy would be to cut off the hard coal traffic and the lumber traffic, and, consequently, it is not to be anticipated that alternative facilities would have to be provided for either of these. Of course this prediction might be in error in that the companies that are interested in lake traffic in coal and lumber might insist upon continuing to operate even at a disadvantage as compared to rail shippers. In such a case it might be necessary to provide lake front unloading equipment, and the lightering of coal or lumber or both from the lake front to points along the river might be attempted, though it seems probable that such a practice would be entirely too expensive to be considered.

Fixing the bridges would also eliminate the lake boat movements to and from the Chicago River grain elevators, and it seems reasonable to suppose that these elevators would cease to function, their business being transferred to South Chicago. The owners expect to be reimbursed for the property loss which would be occasioned if the bridges were fixed, and many of them doubtless will be better pleased to transfer their operations to the Calumet area. It would be possible to move grain by lighter from the elevators to a floating elevator at the Lake front, but there is little reason to believe that the added cost of a lighter movement and transfer by floating elevator (perhaps a cent a bushel) would be justified unless it were as a temporary expedient to eke out the remaining life of existing elevator structures.

Similarly, the sand and gravel business might possibly temporarily require facilities at the Lake front, though these materials can be carried all the way in craft that will pass under fixed bridges and it probably will be so carried when disposition is made of the existing boats that could not possibly be converted to clear the bridges. When the present high clearance craft are disposed of, it is to be expected that the present river sand and gravel yards will serve as well with fixed bridges as they do with movable bridges, and that no special arrangements will have to be made as regards lake front or other terminal facilities.

So far as the package freight commerce is concerned, it is now almost wholly a lake front or river mouth commerce, and there is little reason to anticipate the necessity to provide extensive new facilities if bridges are fixed. It might be desirable for the City to make arrangements whereby any shippers who so desire may establish lake front warehouses with an opportunity for lake boats to unload directly alongside and with adequate rail connections. The lake and rail interchange which is now taken care of over railway docks in the South Branch can be handled about as well at South Chicago. The provision of railway docks there would be a comparatively simple matter.

In other words, the immediate problems as regards the provision of alternative terminal facilities which might be made necessary by the adoption of the fixed bridge policy can be solved easily. So far as the requirements of the next ten years only are concerned, there is relatively little in the way of water terminal facilities or any other water traffic requirements which need receive attention.

Need for Planning Future Developments

On the other hand, some immediate action is highly desirable with respect to provisions for future water traffic. It is important that the City should settle the question of its bridge policy and should decide whether or not it is the lake front or the river that is to provide the future docking space for lake-going vessels. It is important also that the city should settle upon a comprehensive and fairly definite plan for supplying the harbor facilities which will be required if, and as, the water traffic increases. The possibility of the future water-borne commerce running to very much greater tonnages than the present commerce must be considered, and plans should be laid now for harbor construction in order that the growth of the City may be directed in a way not to preclude suitable arrangements being made when and if a much greater commerce becomes a reality.

FIG. 6. TYPICAL COAL UNLOADING EQUIPMENT.

The New Port Commission

The City Council has recently provided by ordinance for a Port Commission, the duty of which is to develop plans for caring for the water traffic interests of the City in the future. It is anticipated that this Commission will prepare a harbor plan which will be a guide in City development, more or less similar in function to the general "Chicago Plan". As the City grows and new parks, streets, and the like are provided, these should be laid out with reference to the probable and possible harbor developments as well as the existing harbors.

Until this Commission makes its studies and reports, it cannot be stated what the City of Chicago officially contemplates in respect to water terminal developments. Even after the Commission reports, it will be impossible to state actually what the requirements of the future water traffic will be, because of the uncertainty of the volume.

Review of Sundry Harbor Proposals

In the concluding paragraphs, however, I will review the general plans which

have been put forward by various interested citizens and by the United States District Engineers and other officials who have been working on water terminal problems; and I will undertake to make a few critical comments on some of these proposals.

First of all, we may note that there are now four Harbor Districts created by ordinance, and a fifth has been much discussed. These may be described briefly as follows:

Harbor District No. 1 includes the Chicago River areas and the area to the north of the mouth of the Chicago River as far as Chicago Avenue. This is the lake front region in which the Municipal Pier is located. The Municipal Pier is Pier No. 2 of a series of four piers that it was contemplated to build. Piers No. 1, 3 and 4 never have been built and possibly never will be.

Harbor District No. 2 extends from the mouth of the Chicago River south as far as Grant Park. There used to be two slips in the end of the head of land covered by this District, but under the 1919 Lake Front Development Ordinance, the Illinois Central Railroad was given permission to fill these slips. Since then there has been little talk of the development of Harbor District No. 2 until very recently. The Interstate Harbor Commission in 1923 called attention to this area as being of more immediate importance than the area which they were asked to study particularly (I shall refer to its report later) and various plans for alternative facilities in case of the adoption of a fixed bridge policy mention the District. It has the advantage of offering rail connections which, while unsuitable for some purposes, would still be vastly superior to those obtainable in the neighborhood of the Municipal Pier. Also, docks located in the lake to the east of the present Morton Salt Company plant would be nearer the heart of the City than docks north of the river mouth.

The plans for Harbor Districts No. 1 and No. 2, drawn by the United States District Engineer's office presuppose the fixing of the Chicago River bridges. A Lake front coal dock and a grain transfer slip indicate this. The railway tracks in District No. 1 are to be reached over the C. N. W. tracks and by car ferry. An alternative plan is the development of new wharf frontage in Harbor District No. 2 rather than in Harbor District No. 1.

Harbor District No. 3 is described in the Lake Front Development Ordinance of 1919, and provision is made for rail connections via the Illinois Central tracks, the St. Charles Air Line, and the Chicago Junction belt line. It contemplates that the water terminal development is to be on made land outside of a wide band of park and lagoon. The heavy expense of filling the land and making the improvements is sufficient reason for predicting that it will not be practicable to develop this district for many years to come. It is not very well located from a trucking point of view since most of the destinations and origins for the freight which might be handled here would be at a considerable distance from the wharves. There is no existing commerce or any in sight that would justify this development.

Harbor District No. 4 includes the Calumet River and Lake Calumet. This area is suitable for industrial use, that is, it is a proper area for industries that want to have excellent rail and water connections but do not have to be near the heart of the City. Any business that has a great deal of L. C. L. freight or has to receive or deliver freight by truck from and to other Chicago houses could not afford to be located in this region, unless its business were in the northeasterly corner at the edge of the intensively developed section of South Chicago. This is a section which is important also for commercial houses that are interested solely in interchange movements of bulk commodities; notably it is the best area for interchange coal docks and for grain elevators. The only industry in the region that has developed so far that uses water transportation to any considerable degree is the steel industry.

The Illiana Harbor has not been recognized by the creation of a Harbor District, and could not be completely recognized in a Harbor District created by ordinance because the area extends outside of the City limits into the State of Indiana. The area embraces the Lake Front and Wolf Lake, and is proposed as a development to take care of the interchange of bulk commodities. It is questionable whether this development will be required for exactly this purpose for many years to come, if ever.

Proposals for barge terminals include the United States District Engineers' plans for a principal development at Ashland Avenue near the forks of the South Branch and to the west of the turning basin and south of the West Fork.

For package freight some such terminal development will be badly needed, and plans undoubtedly should be made which will make it less likely for suitable locations to be occupied in a way that will prevent adequate package freight terminals to be established later when they may be required. It has been proposed also that a package freight barge terminal be provided in the forks and the Main River and at North Avenue. For interchange with rail, a point along the Drainage Canal was suggested, but it is not clear that such a terminal will be needed either for bulk commodities or package freight.

All of these plans are very interesting and, in many respects, inspiring, as indicating visions of future developments in the interests of the public welfare; but aside from the United States Engineer's recent barge terminal suggestions they are somewhat unsatisfactory or insufficient as a guide to City officials or others who may wish to see the future harbors developed on practical and economical lines and who seek an answer to the question, "What should we do now?"

I wish to suggest particularly that there are certain things which should be done now. I believe that those who have worked for the establishment of a Port Commission have the correct idea in emphasizing the necessity for *planning* now. The planning that is needed is not primarily the more visionary kind that attempts to outline the vast schemes for handling package freight commerce running into millions of tons, but is the type to indicate what can and should be done immediately to see that harbor developments will not be precluded by the thoughtless planning of other City improvements, or the pre-empting of needed areas by other uses, and so far as possible, what should be done progressively as water commerce increases if and when it does increase. Plans should be related to individual types of commerce, confusion as to the needs of bulk commodities and general cargo or package freight being eliminated once for all. The actual shippers and the boat companies engaged in the business should have an important place in the councils of the City, and should be given every opportunity to be heard. Every element of transportation cost—including that all-important element, trucking from the wharves to the points of origin or destination—should be considered in connection with all plans.

Railway-Borne Commerce In the Chicago Region and Its Requirements

By E. H. Lee*, Past Pres. W. S. E.

Presented February 20, 1925

This paper gives a birdseye view of the enormous railway traffic of the Chicago district, both freight and passenger. There are certain basic principles, herein described, which govern the orderly development of rail traffic and which must be reckoned with in any plan.—Editor.

THE assigned subject can be covered only in the barest outline within the limits of this paper. Some reference to past conditions in the city and the growth of the steam railroads here will serve as a guide post pointing toward the future.

When the first steam locomotive made its initial trip in the State of Pennsylvania about 100 years ago, Chicago consisted of a house or two, located near the mouth of the Chicago River. The surrounding swamps and marshes made a forbidding site for the future city. Some thirty years later when the first railroad entered Chicago it had become a country village. The streets were unpaved. At some seasons of the year they became seas of mud and signs set up in the middle of the street bearing the legend "No bottom here" were not infrequent. The scattered buildings in the loop were of frame construction and the territory outside was largely vacant.

Metropolitan Chicago is today bounded by the line of the Elgin, Joliet & Eastern Railway, located around the city from 35 to 40 miles distant from its center. This area contains a population of about 4,000,000 people, and it contains about 6000 miles of steam railroad tracks. It has become the great railroad terminal gateway of the country, the terminus of some 25 railroads, including the largest systems in the United States.

No train on any railroad runs beyond Chicago and it is therefore the great transfer point of the country. More than 10% of the freight cars loaded in the whole United States are either loaded or unloaded within this area. The location of the city at the head of Lake Michigan doubtless brought the railroads here, but they have created and continue to support practically all the business and industry of the city.

Each railroad entered the city free from natural barriers, except the Chicago River and the adjacent shores of Lake Michigan. The only other obstacles were caused by the growth of population; and each railroad, as it came in, was located through lands where the values were lowest. The various railroads have developed along well defined lines of growth. The 1915 Report of the Smoke Abatement Committee of the Chicago Chamber of Commerce described this process: "The railroads when they entered Chicago naturally established themselves near the center of the city's population—that is, near the mouth of the Chicago River.*** In the beginning they located their yards outside of the limits of the town where low priced land could be had. In process of time, however, the city expanded, industrial establishments increased, residences multiplied and the railroad yards which originally were outside the city became surrounded by improved property. This process has been repeated so many times that the appearance of the map of present day Chicago suggests that wherever a railroad has chosen to marshal its course there the city has ultimately crowded in".

Railroad transportation may be divided between freight traffic and passenger traffic, and between inbound and outbound business. Freight movements may be subdivided into through, local, and those internal to the metropolitan area. Local and internal movements may be further subdivided between

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business to and from industry tracks, to and from freight houses and to and from team tracks. These last two are considered together in this paper because while one consists largely of less-than-carload (L.C.L.) freight and the other of carload (C.L.) freight, in each case the railroad company has an added duty either in loading, unloading or protecting the freight, and the facilities, usually located close together, are handled by the same local organization.

Freight Traffic

A recent study of the freight transportation situation in Chicago, probably the most thorough and painstaking ever made, discloses the following statistics, using round figures:

Average Daily Movements Through and Local to Chicago

		Inbound		Outbound
Loads, Through		4,000		4,000
Loads, Locals (Freight House and Team Track)	2,000		2,000	
Loads, Locals, Industries	6,000	8,000	3,000	5,000
		12,000		9,000
Empties		3,000		6,000
Totals		15,000		15,000

Movements Internal to Chicago

Loads (C. L.)	3,000	
(L. C. L.)	1,000	4,000
Empties		5,000
Total		9,000

The movement of empty cars in the Chicago area is incidental. The movement of loaded cars is the vital factor in the situation. The varying movements of loaded cars in Chicago in the order of their relative importance are shown thus:

1. Loaded Local Car Movements to and from Industries:

	Cars		
Inbound	6,000		
Internal to Chicago	3,000		
Outbound	3,000		
Total		12,000 or	57%

2. Loaded Local Car Movements to and from Freight House and Team Tracks:

Inbound	2,000		
Internal to Chicago	1,000		
Outbound	2,000		
Total		5,000 or	24%

3. Loaded Through Car Movements Transferred Between Railroads:

Inbound	4,000		
Outbound	4,000		
Total	8,000		
	2	4,000 or	19%
Grand Total		21,000	100%

(Note:—These through transfer movements are counted twice, once inbound and once outbound. In order to determine their relative importance they should be counted only once, and therefore the total is divided by two.)

Let us further consider some of the characteristics of the city's terminal traffic.

Freight Traffic to Industries—57%

More than 4000 industries with private track connections are located within the metropolitan area of Chicago. Smaller industries that require no track connections, similar to the garment industry, may bring the number up to 20,000. The larger industrial plants locate where steam railroad industry track connections are available. New plants locate where land is relatively cheap and track access easy. Old and established plants as they grow are constantly removing from the old locations where plant space is restricted and tracks have become congested, to new areas where ample space is available both for plants and trackage. New industrial areas are constantly springing up within the metropolitan limits of Chicago, and this process will continue. It is therefore apparent that in the growth of the city the industrial plants will take care of themselves and that, with the co-operation of the railroads, this element of the freight traffic of Chicago will be successfully handled along the same general lines of growth and development as in the past.

Freight Traffic to and from Freight Houses and Team Tracks—24%

The freight houses and team tracks of the various railroads entering Chicago are still located in general on their original sites, but changes have come and will persist. The use of the motor truck is playing an increasingly important part in the handling of freight between the store or factory and the freight house and team track. It is also entirely diverting from the steam roads a considerable tonnage of freight traffic destined to nearby points. The use of the motor truck makes possible so-called off-track freight houses, to which freight from the factory or store is handled mixed by wagon or dray, to be there

classified and consolidated for movement to or from the various railroad freight houses in full truckloads. Such off-track freight houses are in successful use in other cities. Universal freight houses, where freight is received mixed for all railroads, to be there classified and loaded into trap cars for delivery to the freight house of each of the road-haul roads, have been growing in number in Chicago.

Both the off-track house and the universal house tend to reduce trucking costs although they usually involve an additional cost of handling for the railroads and a delay of at least 24 hours in shipment. And be it noted that time is an important element in the competition for business with the industries of other cities. Transfer stations located in the outskirts supplementing the work of the down-town freight houses are being increasingly used by the road-haul roads in Chicago. Other improved facilities and methods of freight handling may develop in the future.

These changes illustrate the quite fundamental fact that freight traffic destined to and from freight houses and team tracks differs radically in one characteristic from local freight traffic destined to industries. When congestion comes the industries themselves move to a new and freer site; in the case of freight house and team track traffic, however, past experience indicates that they tend to move to the freight producing area. This difference will have an important influence upon the future development of freight house and team track traffic in Chicago.

Those railroads which have already rebuilt their local freight house and team track facilities have followed the theory that business in and near the loop will continue to increase and that therefore they were justified in providing a substantial increase in these facilities for the future. In any event it seems certain that as the city grows and new centers of freight house and team track tonnage develop, suitable facilities of one kind or another to care for this traffic will be provided near the source of the traffic, thereby relieving the down-town freight houses and team tracks.

Through Freight Traffic between Points Outside of Chicago—19%

In the early days through cars from points outside of Chicago destined to points beyond were interchanged directly between the road-haul roads. With the growth of freight transportation the tendency has been more and more to handle this business over Belt Lines, where the traffic could be moved free from the congestion of the down-town tracks and city streets.

At present traffic of this kind comprises 19% of the total loaded car movements within the metropolitan area, and 75% of this 19% is handled by Belt railroads. The more important Belt Lines have made great improvements and additions to their trucks and facilities during the last decade, so that they have an ample capacity to handle this business. Moreover, it is coming to be understood that most of the delays and congestion charged against the Belt Lines are really caused by congestion on the road-haul roads with their consequent inability to take their business freely. The existing Belt Lines with such additions to permanent way, power and equipment as reasonably may be required by the growth of traffic will be able to handle this through transfer traffic promptly and economically both from an operating and a capital-expenditure point of view for many years to come.

It is to be noted that these through movements are no longer any real part of the freight transportation problem of Chicago. They are already largely removed therefrom and constantly tend to become of less relative importance.

Passenger Traffic

Passenger transportation on the steam railroads of Chicago is divided between through traffic and suburban traffic. More than 500 through passenger trains and more than 800 suburban trains per day enter and leave the city.

Suburban Traffic

Suburban trains were originally put on by the railroads to fill a pressing public need and to utilize tracks and facilities then only partially used. The growth of this traffic recalls the story of the Arab whose camel first thrust his nose into his master's tent, later to crowd in bodily, thereby displacing the master and his family.

Without doubt suburban transportation on the Chicago railroads should continue as at present until this traffic begins to congest and crowd out the through traffic. As between the two, however, through traffic must be given the preference, because suburban and interurban traffic can always be diverted to other transportation routes, whereas no such possibility of diversion exists for the through passenger traffic of the steam railroads.

The population of New York City is greater than that of Chicago and her suburban and interurban problem is more pressing then ours. Suburban passenger traffic is already so greatly congesting the tracks and terminals of the steam railroads of that city as seriously to interfere with through business. A plan has been prepared and is being considered for the construction of a belt subway on Manhattan Island, to which the suburban trains of all railroads can be diverted at points distant from the through passenger terminals, thereby relieving the congestion, while at the same time landing suburban passengers on the average much closer to their destination than under the existing arrangement. Some such diversion of the suburban traffic of Chicago from the through passenger terminals apparently may be expected in the future.

Through Passenger Traffic

Chicago is the great gateway for the through traffic of the country, passengers from all points changing cars here. One strongly marked characteristic appears in the great passenger stations of the country. With few exceptions they tend to remain close to the business centers of their respective cities. They may move closer in, but seldom move farther out, the reason being that the business center is the point most easily reached by the greatest number of people. Proximity thereto seems to be the best measure of convenience. The location of the through passenger terminal is therefore less subject to change than the railroad terminal of any other kind. This being the almost universal characteristic of a great passenger terminal, it might be thought that great care would be used to make the various units of this the most permanent of the different types of railroad terminals, large enough reasonably to meet the demands of the future. And yet, notwithstanding the amazing changes in the last 50 years, doubtless to be equalled in the next half century, the usual plan seems to have been to rebuild when necessary for only 20 or 30 years in the future (not a bad plan in itself it may be said) but fundamentally defective if no definite plans are made for future extensions, to be constructed at moderate cost when needed.

Now the struggle for profit is the main incentive leading to improvements in facilities and methods for the railroads, as for other forms of business and industrial activity. And profit involves the keeping of expenditures to the lowest practicable terms, upon an economic basis.

The railroads of the city have generally followed the economic line of least resistance. If their projectors and constructors could have had some picture of present day conditions a better general arrangement of tracks and facilities might have been made. So too, if the streets in the Loop had been laid out 200 feet wide it would have been tremendously advantageous. But the thought of what might have been is equally futile in either case.

It will be interesting to inquire what attitude the railroads may be expected to adopt toward the question of reconstructing their facilities in the Chicago Metropolitan Area.

The Association of Railway Executives has issued a statement to the public under date of Nov. 19, 1924, containing a record of achievement and a declara-

tion of principles relating to the steam railroads of the country. Among these principles applicable to the question are the following:

"That all railroad problems as they arise should be dealt with and settled as economic questions, which they are, and not as political issues, which they are not."

"That the railroads are determined to continue their policy of expansion to provide adequate transportation for the increasing commerce of the country and to strive in every way to bring about greater efficiency in operation and a progressive reduction in costs."

How effective this policy is, is shown by the statements in the document that—"since 1915 new capital to the amount of $3,896,000,000 has been invested in Class I roads;" and that "during the year 1923 the carriers handled the greatest freight traffic ever offered in any similar period of time in the history of the country, and with an unparalleled degree of success."

"That a continuation of adequate transportation facilities and service carries as an inevitable corollary the necessity for adequate revenues to be earned and retained in order that railroad credit may be restored and re-established in the confidence of investors and that ample additions, improvements and repairs may be made at reasonable financial costs."

This statement made for the country at large is equally applicable to Chicago.

The railroads west of the Chicago River have completed the reconstruction of their passenger terminals, and with one exception their freight houses and team tracks. The railroads on the Lake Front have covered their similar situation by acquiring real estate and accepting ordinances, thus settling upon their reconstruction program. This leaves only the 14 railroads, included in the three groups known as the B. & O., LaSalle and Dearborn Station groups still to formulate plans for the reconstruction of their freight and passenger terminals. These railroads occupy a territory roughly bounded by Van Buren Street on the north, State Street on the east, Archer Avenue on the south, and the Chicago River on the west.

The late James J. Hill said "Ample and accurate information is the first step toward success." It is the first step in the scientific method by which scientists have made all the marvelous advance in the realm of material things during recent times.

A painstaking study of the facts pertaining to the steam railroad situation in Chicago has been made recently by a number of able railroad men selected from the Engineering, Operating and Traffic Departments. The results of this study give a better basis than has been available before for an analysis of existing conditions, and for some forecast as to the future.

Several reports on the Chicago Terminal Situation have been made in recent years. The most important of these is that made in 1915 by John F. Wallace, Chairman, Chicago Railway Terminal Commission. This report made several valuable suggestions, and it has been widely read. It recommended the straightening of the Chicago River, something well nigh indispensable to the future of the city; it recommended that all streets over the area occupied by the fourteen railroads be carried up on viaducts, the ground level under which was to be occupied by rearranged railroad tracks and facilities; and it recommended the use of the air rights over tracks for the development of business structures of various kinds, as has been done in the case of the Grand Central Terminal in New York.

These recommendations deserve unstinted praise. They are to the equal advantage of the public and the railroads. However, the report falls into the fundamental error of urging the removal of Passenger Terminal Facilities to the Lake Front, and the sale of all railroad property east of Clark Street to private interests. The whole transaction, i.e., the sale of property and the cash value of air rights, less the cost of river straightening, viaducts, and railroad improvements, was estimated to show a profit of $43,000,000.

Business property is valuable in pro-

portion to the number of people coming to or passing by it. Passenger station improvements attract people and freight yards and stations drive them away. For this and other good reasons the assumed value of railroad property to be sold and air rights to be leased have been found upon careful analysis to be more than twice too high, and the estimated cost of improvements using present unit prices is only one-half large enough; so that the alleged profit of $43,000,000 becomes an outgo of more than that amount, an error in this estimate of financial results of $90,000,000.

Furthermore, a feature of this report, apparently made upon assumptions unchecked by a careful scrutiny of the available facts, is the recommendation that passenger facilities be removed from a site already owned by the railroads and fully ample for the purpose, as detailed plans have shown, to another site twice as far from the business center, and much less accessible to passengers. Such a plan would mean a serious financial loss to the 14 railroads. It would be of manifest disadvantage and loss to the public because it would greatly delay if not entirely stop business development to the south of the loop; and it would remove the passenger station facilities from a site having direct contact with at least five north and south streets and several east and west streets, most of them well adapted for through urban transportation routes to another location twice as far distant from the business center, having direct contact with only two north and south streets, and one east and west street, none of which are adapted for through urban transportation routes, and only one for a local stub route.

Pedestrians and patrons of urban transportation systems would therefore be greatly inconvenienced, and patrons travelling by taxi and motor, except those coming from a narrow fringe along the lake shore to the north and south, would lose both time and money.

A second report, the so-called *Warfield Report on Joint Terminals at Chicago*, made under private auspices and issued March 28, 1922, is an example of a meager development of information, with the erroneous conclusions thereby entailed. *As to Passenger Traffic*, the Wallace Report was assumed to be correct and its conclusions were adopted without investigation.

As to Freight Traffic, the Warfield Report recommends the expenditure of over $50,000,000 for improvements to handle Chicago's Freight Traffic. The report evidently assumes that through transfers make up the bulk of the total movement, whereas this movement is only 19% of the whole, three-quarters of which is now being handled promptly and economically over some one of the various Belt Lines. The remainder can be equally well handled both now and in the future, and therefore the expenditure of most of this great sum is recommended to meet a need that does not exist.

This Report also recommends the unification of all Chicago railroad terminals, a plan under which the separate operation and control of the road-haul roads would cease at the line of the Elgin, Joliet & Eastern Railway. Such a radical change in operation would be undesirable alike to public and private interests, because it is contrary to the entire trend of growth of the railroads in Chicago.

River Straightening

Straightening of the Chicago River is primarily a great civic improvement, quite similar to the widening of North Michigan Boulevard. River straightening will accomplish greatly more in increasing access to the South Side, per dollar of expenditure, than did the widening of the Boulevard for the North Side. The railroads can no more straighten the river than could the abutting property owners have widened Michigan Boulevard. The City must inaugurate and carry through this work, and the City authorities appreciate this. The Mayor in an able message to the Council (See Proceedings October 22nd, 1924) said—"The straightening of the Chicago River as proposed would permit the opening of three additional streets to the South without crossing the

River.*** It has been my constant effort since taking office to bring about the early accomplishment of this most needed and tremendously important improvement."

Between the River and the Lake, there are at present 9 north and south streets north of Van Buren Street, and 4 south of the same. With the 3 proposed additional streets south of Van Buren the number will be 7, an increase in access to the loop from the South Side of at least 75%.

The writer is not authorized to speak for the railroads, but he feels that they will be ready and willing to co-operate with the City fully and fairly. They are both in the same boat as to the fundamental feature of this great improvement.

Air Rights

With the placing of present and future streets upon viaducts within the boundaries of the present railroad occupation, the ground level under the viaducts will be left free for rearranging railroad tracks and facilities, and such a rearrangement should contemplate the use of the overhead space for the construction of business buildings similar to the present buildings in the Loop. This is entirely practicable and is financially desirable for all interests. The air rights development over the Grand Central Terminal in New York City is the pioneer and a beautiful example of what should be done. This plan will increase the area for business development where it is most needed; it will close up an ugly gap in the development of the business district caused by the present old style railroad improvements; and ultimately it will help the railroads to carry an increased capital expenditure, burdensome at best.

Future Improvements

The fourteen railroads occupying the territory between State Street and the River, organized a careful study of the situation several months ago. Great progress has been made in collecting information pertinent to the subject. The general basis for the investigation is first to determine in a general way the location and size of passenger facilities adequate for the future, of a type best fitted to all the conditions; and thereafter to determine upon the freight facilities of a like type, up to the capacity of the area available. The study takes into account the straightening of the River, the placing of streets upon viaducts, together with a rearrangement of railroad improvements, and an air right development to conform.

Summarizing the Chicago Terminal situation, the probabilities seem to be: *that congestion will continue to appear from time to time;* because of the growth of population and business; and congestion is about the only evidence of the need of enlarged facilities that is considered valid and conclusive by either railroad managements or public regulating bodies;

that Local Freight Traffic to Industries will generally find relief from congestion by the removal of the industries themselves to new locations, free from the old restrictions:

that Freight House and Team Track Traffic will tend to find relief from congestion, by the development of new units of the various required kinds, located adjacent to new freight producing areas, and supplementing the old facilities;

that Through Transfer Freight Traffic will continue to move over existing Belt Lines in greater volume, using tracks and improvements enlarged as becomes necessary.

that Suburban Passenger Traffic will continue as at present until it congests and limits Through Traffic, probably then to be diverted to other available routes of urban transportation;

and that Through Passenger Traffic will continue to increase, and to enter Terminals that cling to the heart of the city; that these Terminals are more nearly fixed and immoveable than any other kind of railroad terminal improvements; and that consequently, unless future requirements have been wisely forseen and provided for in present plans, the means then used to meet the later growth of this traffic either by the enlargement of the terminals or by the development of other alternatives will cost enormously more than railroad improvements of any other kind.

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The Transmission of Pictures by Telephone

By DR. HERBERT E. IVES*

Presented October 20, 1924

An achievement which has startled the technical world, but which is accepted by the rest of the world as something to be expected of scientists is here described in detail. The successful development of this process is an accomplishment of which the authors may well be proud. It is a long step forward. The Society is fortunate to have had this paper presented before it and to be the first to publish a detailed account of this process.—Editor.

THE idea of transmitting pictures by electricity is quite old; the first schemes for doing this having been suggested only a few years after the development of the first electric telegraph. Actual experiments in picture transmission date from the last years of the nineteenth century, and the broad principles of picture transmission have been recognized for some time[1]. The method of picture transmission which is here described differs from earlier experimental methods in that it is adapted for use on the present day telephone system. The quality of the results attained is largely due to the perfection of the telephone; in particular, to developments which have taken place within the last few years. New developments which have facilitated picture transmission are the photoelectric cell, the vacuum tube amplifier, electrical filters and the use of carrier currents.

The work which the writer has the privilege of describing here is actually that of a large number of engineers who have collaborated in its various phases. Among the collaborators who are responsible for many of the elements and methods described, the writer wishes particularly to mention Messrs. J. W. Horton and M. B. Long of the Bell Telephone Laboratories, Inc., and Messrs. R. D. Parker and A. B. Clark of the American Telephone and Telegraph Company.

General Scheme of Picture Transmission:

Reduced to its simplest terms, the problem of transmitting a picture electrically from one point to another calls for three essential elements: The first is some means for translating the lights and shades of the picture into some characteristic of an electric current; the second is an electrical transmission channel capable of transmitting the characteristic of the electric current faithfully to the required distance; the third is a means for retranslating the electrical signal as received into lights and shades, corresponding in relative values and positions with those of the original picture.

Analyzed for purposes of electrical transmission, a picture consists of a large number of small elements, each of substantially uniform brightness. Figure 1, illustrates the analysis of a picture into small elements. In this case the picture

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[1]A comprehensive account of earlier work in Picture Transmission will be found in "Telegraphic Transmission of Pictures," T. Thorne Baker, Van Nostrand, 1910, and the "Handbuch der Phototelegraphie und Telautographic," Korn and Glatzel, Nemnich, 1911.

is divided up into about two hundred small squares. This number should, however, for practical purposes, be increased to something like 10,000. The transmission of an entire picture necessitates some method of traversing or scanning these elements. In Figure 1, the dotted line at the top represents the passage of a scanning device back and forth across the elements of the picture. The method of scanning used in the present apparatus is to prepare the picture as a film transparency which is bent into the form of a cylinder. The cylinder is then mounted on a carriage, which is moved along its axis by means of a screw, at the same time that the film cylinder is rotated. A small spot of light thrown

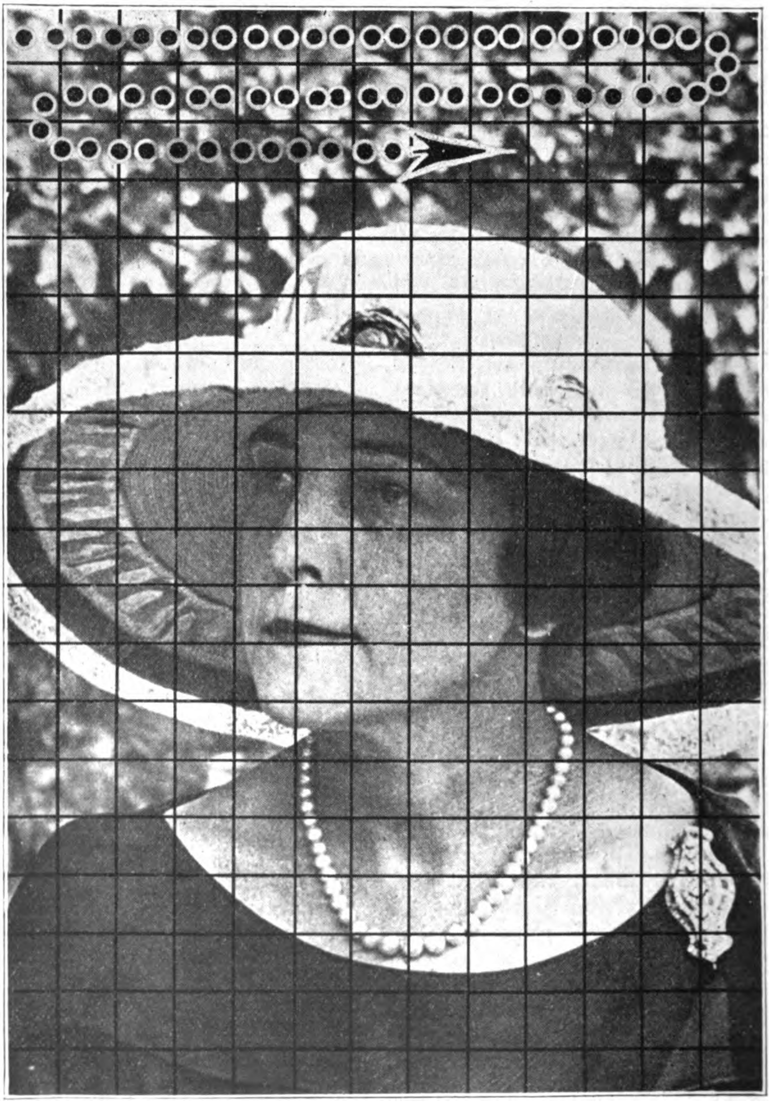

FIG. 1—ANALYSIS OF PICTURE INTO SMALL ELEMENTS, TO BE SCANNED SUCCESSIVELY BY LIGHT SENSITIVE DEVICE.

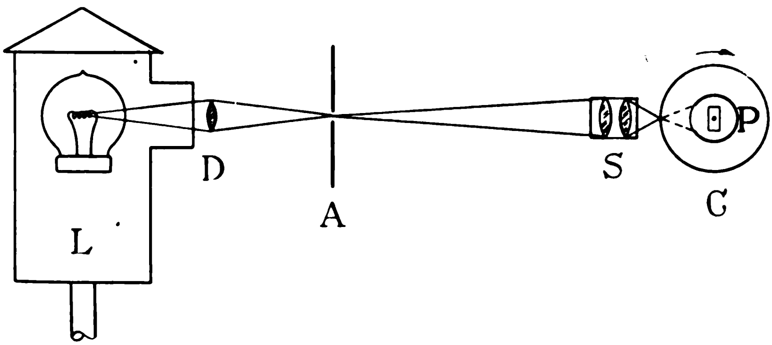

FIG. 2—SENDING END OPTICAL SYSTEM IN SECTION: (L) LIGHT SOURCE: (D) CONDENSING LENS; (A) DIAPHRAGM; (S) PROJECTION LENS; (C) TRANSPARENT PICTURE FILM IN CYLINDRICAL FORM; (P) PHOTOELECTRIC CELL.

upon the film is thus caused to traverse the entire film area in a long spiral. The light passing into the interior of the cylinder then varies in intensity with the transmission or tone value of the picture. The optical arrangement by which a small spot of light is projected upon the photographic transparency is shown in section in Fig. 2.

The task of transforming this light of varying intensity into a variable electric current is performed by means of an alkali metal photoelectric cell. This device, which is based on the fundamental discovery of the photoelectric effect by Hertz, was developed to a high degree of perfection by Elster and Geitel. It consists of a vacuum tube in which the cathode is an alkali metal, such as potassium. Under illumination, the alkali metal gives off electrons, so that when the two electrodes are connected through an external circuit, a current flows. This current is directly proportional to the intensity of the illumination, and the response to variations of illumination is practically instantaneous. A photograph of a photoelectric cell of the type used in the picture transmission apparatus is shown in Fig. 3. This cell is placed inside the cylinder formed by the photographic transparency which is to be transmitted, as shown in Fig. 2. As the film cylinder is rotated and advanced, the illumination of the cell and consequently the current from it registers in succession the brightness of each elementary area of the picture.

Assuming for the moment that the photoelectric current, which is a direct current of varying intensity, is of adequate strength for successful transmission, and that the transmission line is suitable for carrying direct current, we may imagine the current from the photo-

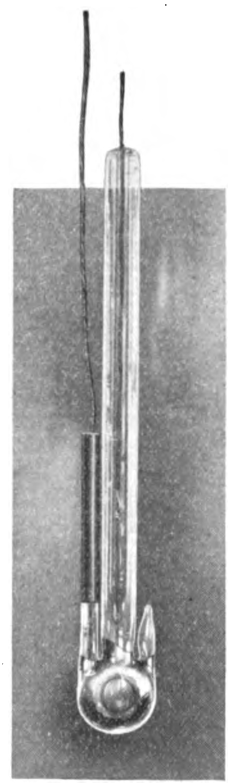

FIG. 3—PHOTOGRAPH OF PHOTOELECTRIC CELL OF TYPE USED IN PICTURE TRANSMISSION.

electric cell to traverse a communication line to some distant point. At the distant point it is necessary to have the third element above mentioned, a device for retranslating the electric current into light and shade. This is accomplished in the present system by a device, due in its general form to Mr. E. C. Wente,

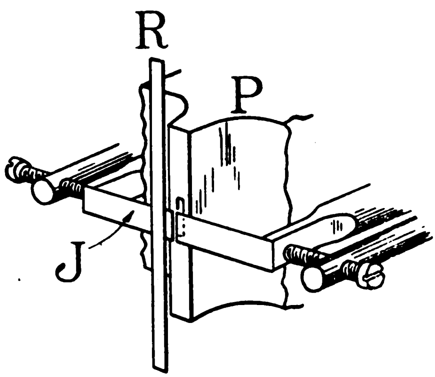

FIG. 4—LIGHT VALVE DETAILS: (R) RIBBON CARRYING PICTURE CURRENT; (P) POLE PIECE OF MAGNET; (J) JAWS OF APERTURE BEHIND RIBBON.

termed a "light valve." This consists essentially of a narrow ribbon-like conductor lying in a magnetic field in such a position as to entirely cover a small aperture. The incoming current passes through this ribbon, which is in consequence deflected to one side by the interaction of the current with the magnetic field, thus exposing the aperture beneath. Light passing through this aperture is thus varied in intensity. If it then falls upon a photographic sensitive film bent into cylindrical form, and rotating in exact synchronism with the film at the sending end, the film will be exposed by amounts varying in proportion to the lights and shades of the original picture. The ribbon and aperture of the light valve are shown diagrammatically in Fig. 4. Fig. 5 shows a section of the receiving end of a system of the sort postulated, with its light source, the light valve, and the receiving cylinder.

Adaptation of Scheme to Telephone Line Transmission:

The simple scheme of picture transmission just outlined must be modified in order to adapt it for use on commercial electrical communication systems, which have been developed primarily for other purposes than picture transmission. Of existing electrical means of communication, which include land wire systems (telegraph and telephone), submarine cable, and radio, the wire system, as developed for the telephone, offers great advantage when all factors are considered, including constancy, freedom from interference and speed. The picture transmission system has accordingly been adapted to it.

In the simple scheme of picture transmission outlined in the preceding section, the photoelectric cell gives rise to a direct current of varying amplitude. The range of frequency components in this current runs from zero up to a few hundred cycles. Commercial long distance telephone circuits are not ordinarily arranged to transmit direct or very low

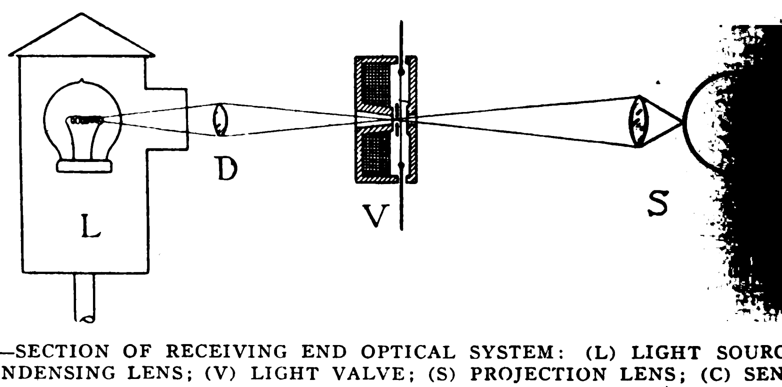

FIG. 5—SECTION OF RECEIVING END OPTICAL SYSTEM: (L) LIGHT SOURCE; (D) CONDENSING LENS; (V) LIGHT VALVE; (S) PROJECTION LENS; (C) SENSITIVE FILM.

FIG. 6—PORTION OF TRANSMITTED PICTURE OF VARIABLE WIDTH LINE TYPE, ENLARGED.

frequency currents, so the photoelectric currents are not directly transmitted. Moreover, these currents are very weak in comparison with ordinary telephone currents. On account of these facts, the current from the photoelectric cell is first amplified by means of vacuum tube amplifiers[2] and then is impressed upon a vacuum tube modulator jointly with a carrier current whose frequency is about 1,300 cycles per second. What is transmitted over the telephone line is, then, the carrier wave[3] modulated by the photoelectric wave so that the currents, in frequency range and in amplitude, are similar to the currents corresponding to ordinary speech.

When the carrier current, modulated according to the lights and shades of the in this the black lines are traces of the image of the light valve aperture. Superposed on the larger variations of width, which are proportional to the light and shade of the picture, small steps will be noted (particularly where the line width varies rapidly); these are caused by the carrier pulses.

Synchronization

In order that the light and shade traced out on the receiving cylinder shall produce an accurate copy of the original picture, it is necessary that the two cylinders rotate at the same uniform rate. This, in general, demands the use of accurate timing devices. The means employed in the present apparatus consist of phonic wheels or impulse motors con-

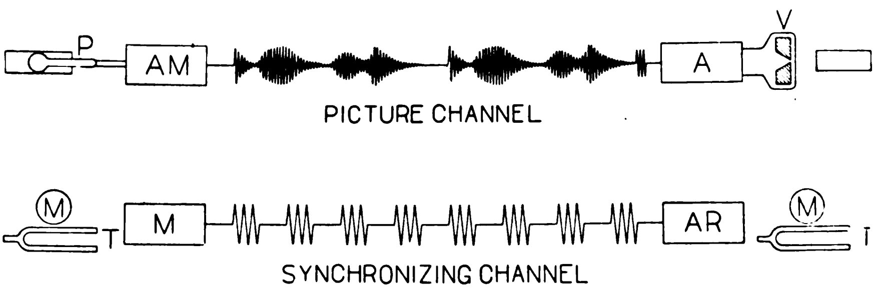

FIG. 7—DIAGRAMMATIC REPRESENTATION OF THE PICTURE AND SYNCHRONIZING CURRENTS. (P) PHOTOELECTRIC CELL; (AM) AMPLIFIER MODULATOR; (A) AMPLIFIER; (V) LIGHT VALVE; (M) PHONIC WHEEL MOTORS; (T) TUNING FORKS; (AR) AMPLIFIER RECTIFIER.

picture at the sending end, traverses the ribbon of the light valve at the receiving end, the aperture is opened and closed with each pulse of alternating current. The envelope of these pulses follows the light and shade of the picture, but the actual course of the illumination with time shows a fine structure, of the periodicity of the carrier. This is shown by the enlarged section of a picture, Fig. 6; trolled by electrically operated tuning forks[4]. Were it possible to have two forks at widely separated points running at exactly the same speed, the problem of synchronizing would be immediately solved. Actually this is not practical, since variations of speed with temperature and other causes prevent the two forks from operating closely enough together for this purpose. If the two cylinders are operated on separate forks, even though each end of the apparatus runs at a uniform rate, the received picture will, in general, be skewed with respect to the original. The method by which this difficulty has been overcome in the present instance is due to Mr. M. B.

[2]For a very full description of the standard telephone repeater the reader is referred to "Telephone Repeaters," Gherardi and Jewett, Trans. A. I. E. E., Nov., 1919, Vol. 38, part 2, pp. 1287-1345.

[3]A description of electrical communication by means of carrier currents will be found in "Carrier Current Telephony and Telegraphy," Colpitts and Blackwell, Trans. A. I. E. E., 1921, Vol. 40, pp. 205-300. A discussion of the relations between the several components of the signal wave employed in carrier is given in "Carrier and Sidebands in Radio Transmission," Hartley, Proc. I. R. E., Feb., 1923, Vol. 11, No. 1, pp. 34-55.

[4]A detailed description of the construction and operation of the impulse motor and its driving fork is given in "Printing Telegraph Systems," Bell Trans. A. I. E. E., 1920, Vol. 39, Part 1, pp. 167-230.

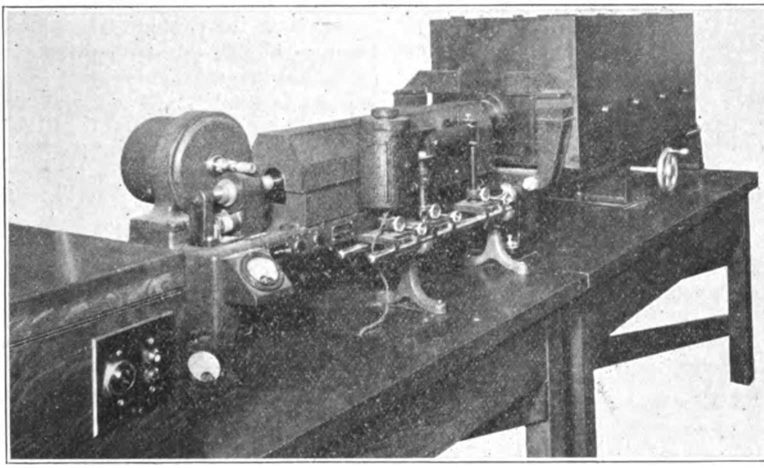

FIG. 8—SENDING END APPARATUS.

Long. Fundamentally, the problem is solved by controlling the phonic wheel motors at each end by the same fork. For this purpose it has been found desirable to transmit to the receiving station impulses controlled by the fork at the sending end. The problem of transmitting both the fork impulses and the picture current simultaneously could be solved by the use of two separate circuits. If this were done the currents going over the two lines would be substantially as shown in Fig. 7, where the upper curve represents the modulated picture carrier for two successive revolutions of the picture cylinder, and the lower curve shows the synchronizing carrier current modulated by the fork impulses.

It would not, however, be economical to use two separate circuits for the picture and synchronizing channels, consequently the two currents are sent on the same circuit. In order to accomplish this, the picture is sent on a higher frequency

[5]The vacuum tube oscillator as a source of carrier current is described in Colpitts and Blackwel, Loc. Cit. A general discussion of the vacuum tube oscillator is given in the "Audion Oscillator," Heising, Jour. A. I. E. E., April and May, 1920. A discussion of the arrangement of the particular oscillator used with the picture transmission equipped is given in "Vacuum Tube Oscillator," Horton, Bell System Tech. Jour., July, 1924, Vol. 3, No. 3, pp. 508-524.

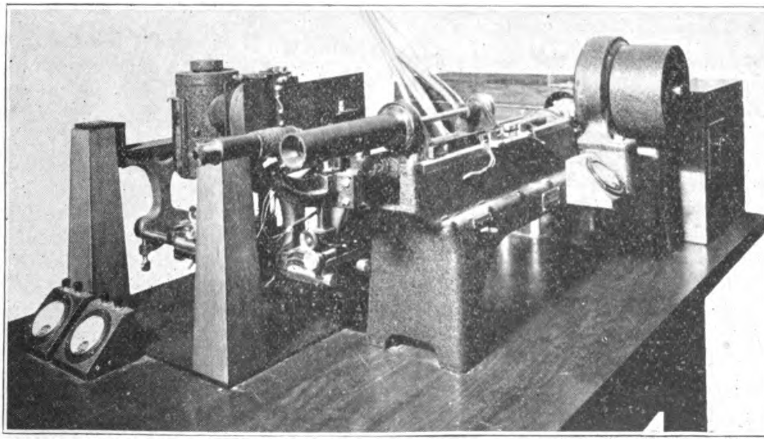

FIG. 9—RECEIVING END APPARATUS.

carrier, approximately 1,300 cycles per second, and the synchronizing pulses are sent on the lower frequency carrier, approximately 400 cycles per second, both lying in the range of frequencies readily transmitted by any telephone circuit. These carrier frequencies are obtained from two vacuum tube oscillators[5]. The two currents are kept separate from each other by a system of electrical filters at the sending and receiving ends, so that while the current on the line consists of a mixture of two modulated frequencies, the appropriate parts of the receiving apparatus receive only one carrier frequency each[6].

appears at the center. The phonic wheel motor and the box containing the tuning fork appear at the right.

Electrical Circuits

The essential parts of the electrical circuits used are shown in the schematic diagram, Fig. 10 and 10A, in which the various elements which have been described previously are shown in their relations to each other.

Certain portions of the electrical circuits deserve somewhat detailed treatment. One of these is the amplifier-modulator system for the picture channel, the other is the filter system employed

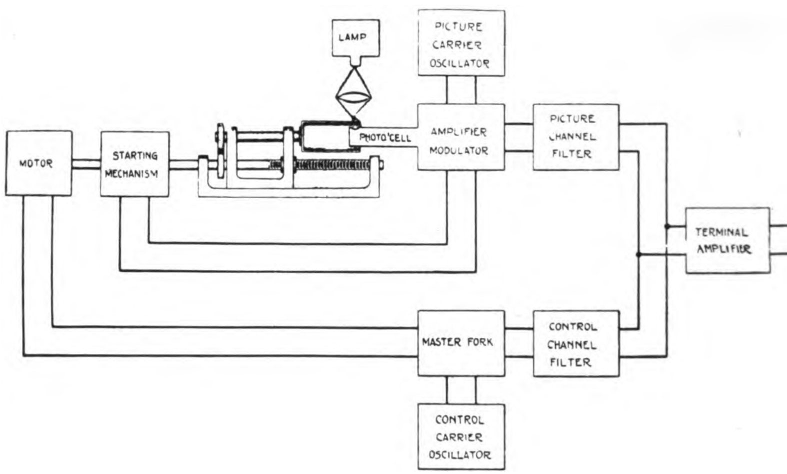

FIG. 10—SCHEMATIC DIAGRAM OF SENDING-END CIRCUITS.

for separating the picture and synchronizing channels.

In Fig. 11 is shown (at the top) a diagram of the direct current amplifier and the modulator used for the picture channel, together with diagram (at the bottom) showing the electrical characteristics of each element of the system. Starting at the extreme left is the photoelectric cell, the current from which passes through a high resistance. The potential tapped off this resistance (of the order of 30 or 40 millivolts) is applied to the grid of the first vacuum tube amplifier. The second vacuum tube amplifier is

Description of Apparatus:

Mechanical Arrangements

The essential parts of the mechanism used for rotating and advancing the cylinder at the sending station, and for holding the photoelectric cell and the amplifying and modulating system are shown in the photograph, Fig. 8. At the extreme left is a box containing the driving fork, to the right of this is the phonic wheel impulse motor which drives the lead screw through a spiral gear.

The receiving end mechanism for turning and advancing the cylinder is similar to that at the sending end, and is shown in Fig. 9. In this photograph, the light valve is at the left of the photograph, and the metal cylinder, around which the sensitive photographic film is wrapped,

[6]The application of wave filters to multi-channel communication systems is discussed in Colpitts and Blackwell, Loc. Cit. More complete discussions are to be found in: "Physical Theory of Electric Wave Filters," Campbell, Bell System Tech. Jour. Nov., 1922, Vol. 1, No. 2, pp. 1-32.

similarly coupled with the first, and the vacuum tube modulator in turn to it. The relationship between illumination and current in the photoelectric cell is, as shown in diagram No. 1, linear from the lowest to the highest value of illumination. The voltage-current (E versus I) characteristics of the amplifying tubes and the modulating tube circuits are shown in the figure by the diagram which lie immediately below these tubes. They are not linear over their whole extent. It becomes necessary, therefore, in order to preserve the linear characteristic, which is essential for faithful picture transmission, to locate the range of variation in each of the latter tubes on a linear portion of their characteristics. This is accomplished by appropriate biasing voltages (Eg), as shown. As a consequence of this method of utilizing the straight line portions of the tube characteristics, the current received at the far end of the line does not vary between zero and finite value, but between two finite values. This electrical bias is exactly matched in the light valve by a mechanical bias of the jaws of the valve opening.

Fig. 12 shows diagrammatically the form of the band pass filters used for separating the picture and synchronizing channels, together with the transmission characteristics of the filters. The synchronizing channel filter transmits a narrow band in the neighborhood of 400 c. p. s., the picture channel filter a band between 600 and 2,500 c. p. s.

In addition to the main circuits which have been discussed, arrangements are made for starting the two ends simultaneously and for the transmission of signals. These functions are performed by the interruption of the picture current working through appropriate detectors and relays. Testing circuits are also provided for adjusting the various elements without the use of the actual transmission line.

The Transmission Line

In view of the fact already emphasized, that the currents used in picture transmission are caused to be similar both as to frequency and amplitude to those used in speech transmission, it follows that no important changes in the transmission characteristics of the telephone line are called for. With regard to the frequency range of the alternating currents which must be transmitted and also the permissible line attenuation, the transmission of pictures is less exacting on the telephone line than is speech transmission. In certain other respects, however, the requirements for picture transmission are more severe. For speech, the fundamental requirement is the intelligibility of the result, which may be preserved even though the transmission varies somewhat during a conversation. In the case of picture transmission, variations in the transmission loss of the line, or noise appearing even for a brief instant during the several minutes required for transmission are all recorded and presented to view as blemishes in the finished picture. Pic-

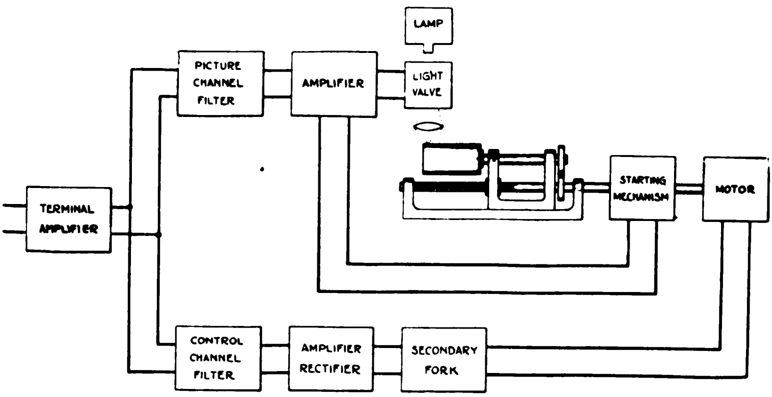

FIG. 10A—SCHEMATIC DIAGRAM OF RECEIVING-END CIRCUITS.

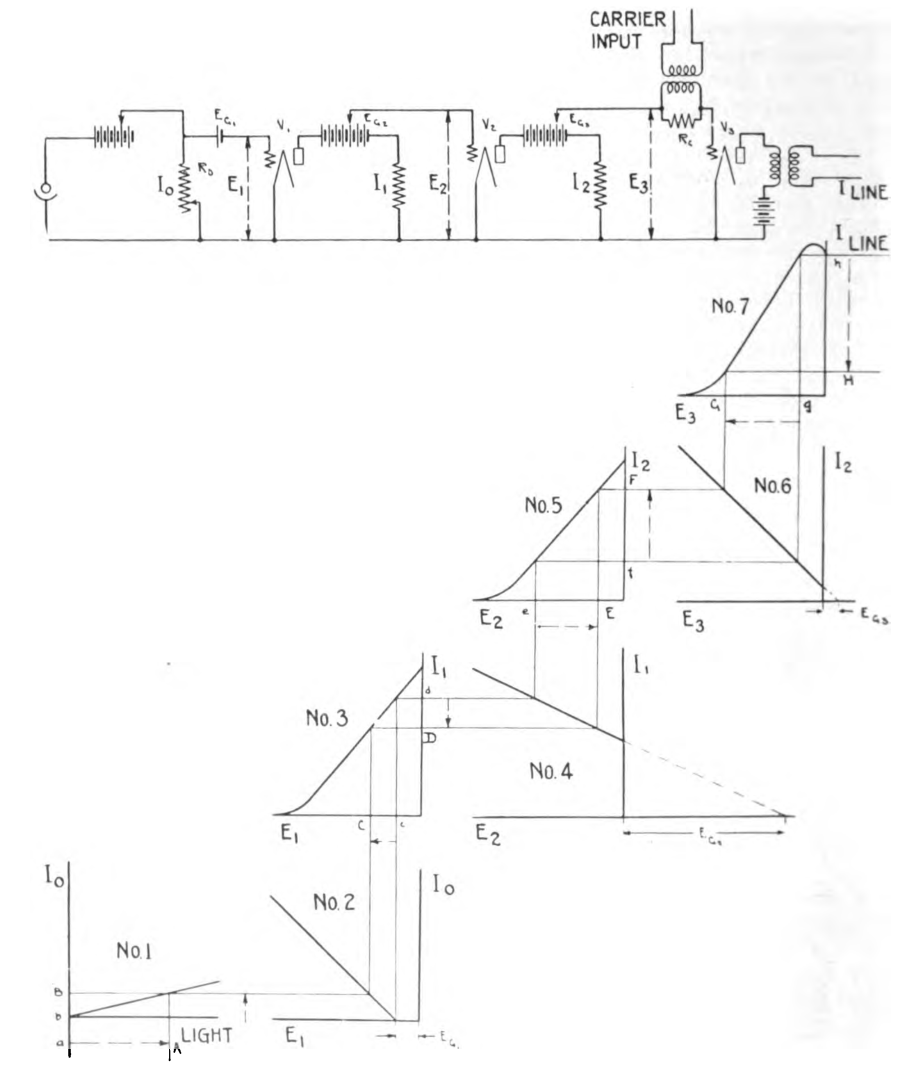

FIG. 11—CIRCUIT SCHEMATIC OF AMPLIFIER-MODULATOR WITH CHARACTERISTICS OF EACH ELEMENT.

ture transmission circuits must, therefore, be carefully designed and operated so as to reduce the possibility of such disturbances. In transmitting pictures over telephone lines, it is also necessary to guard against certain other effects, including transient effects and "echoes" caused by reflections from impedance irregularities. A high degree of balance between the lines and their balancing networks at repeater points is also required. These conditions can be satisfactorily met on wire telephone lines. Radio communication channels are inherently less stable and less free from interference, and special means to overcome their defects are required in order to secure highgrade pictures.

Characteristics of Received Pictures

All electrically transmitted pictures have, as a result of the processes of

scanning at the sending and receiving ends, a certain amount of structure, on the fineness and character of which depends the detail rendering of the result.

One element of structure to be chosen is the number of lines or strips per unit length of the picture. This must be high enough so that at ordinary viewing distance the picture detail is not obscured by the line structure. At the same time, it must be remembered that the speed of picture transmission is inversely as the fineness of structure so that a practical compromise must be reached. In the direction along the lines of the picture, the detail rendering power is conditioned by the widths of the slits at the sending and receiving ends, by the speeds of rotation of the cylinders, and by the transmission characteristics of the line. A practical problem in the design of picture transmission apparatus is to choose the speed of rotation of the cylinder with refer-

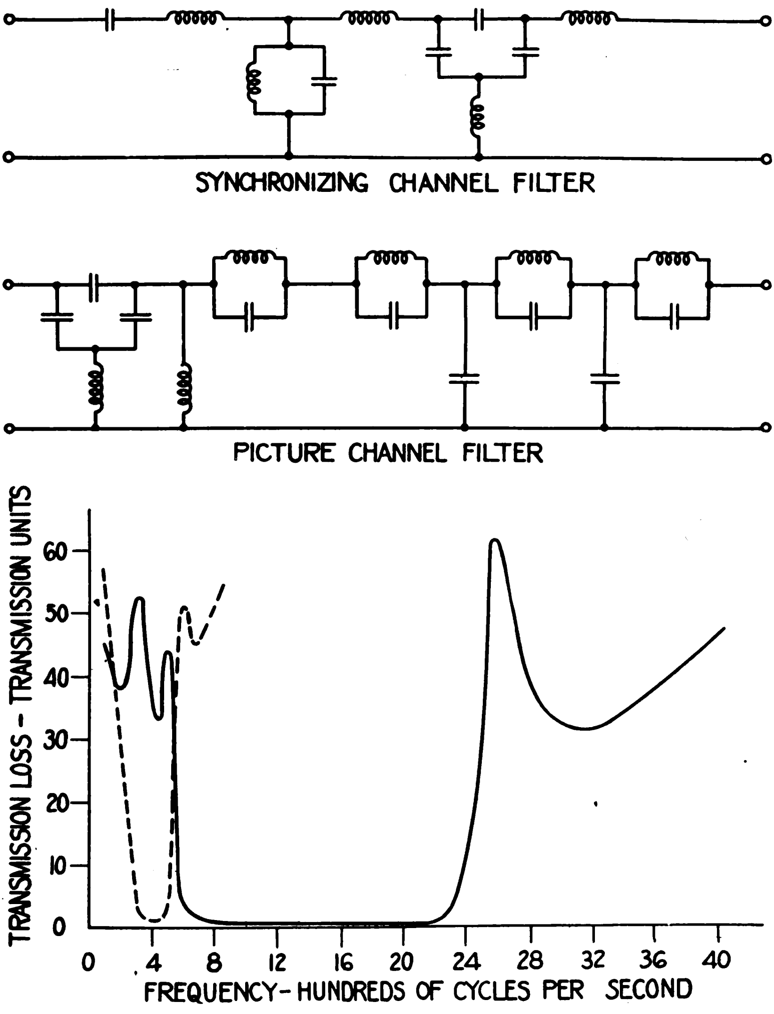

FIG. 12—CIRCUIT SCHEMATICS (ABOVE) AND ATTENUATION CHARACTERISTICS (BELOW) OF PICTURE (FULL LINE) AND SYNCHRONIZING (DASHED LINE) CHANNEL FILTERS.

FIG. 13—EXAMPLE OF VARIABLE WIDTH LINE PICTURE.

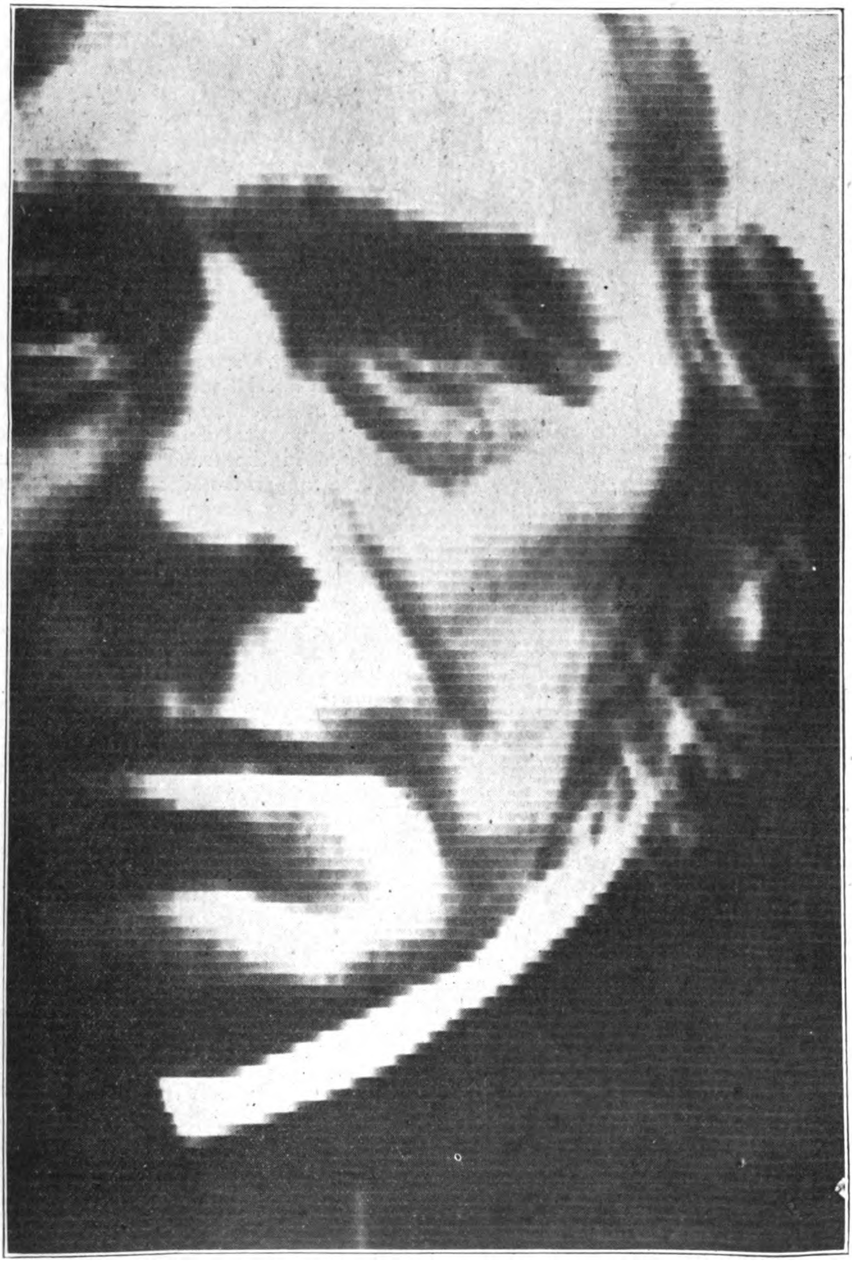

FIG. 14—PORTION OF TRANSMITTED PICTURE OF VARIABLE DENSITY LINE TYPE, ENLARGED.

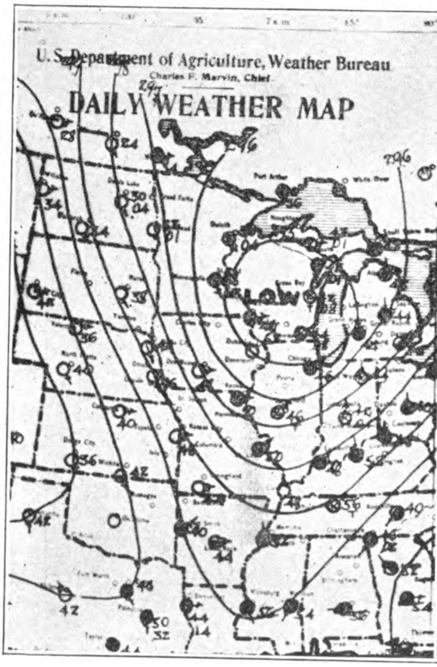

FIG. 15—WEATHER MAP, TRANSMITTED BY TELEPHONE.

ence to the loss in resolving power incident to transmission, so that definition is substantially the same across and along the constituent picture lines.

There are, in general, two methods by which a transmitted picture may be received; one of these is to form an image of the light valve aperture on the sensitive photographic surface. When this is done the picture is made up of lines of constant density and varying width. An enlarged portion of such a picture has been shown in Fig. 6, and a natural size picture of the same sort is shown in Fig. 13. A merit of this kind of picture (when received in negative form) is that if the structure is of suitable size (55 to 65 lines to the inch) it may be used to print directly on zinc and thus make a typographic printing plate similar to the earlier forms of half tone, whereby the loss of time usually incident to copying a picture for reproduction purposes may be avoided. A disadvantage of this form of picture is that it does not lend itself readily to retouching or to change of size in reproduction.

Another method of picture reception is to let the light from the light valve fall upon the film in a diffused manner through an aperture of fixed length, so that exactly juxtaposed lines of constant width, but of varying density are produced. An enlarged portion of a variable density picture is shown in Fig. 14, and an example of a complete picture is shown in Fig. 19. Prints made from film negatives received in this way, if the structure is chosen fine enough—100 lines to the inch or more—are closely similar in appearance to original photographic prints, and may be reproduced through the ordinary half tone crossline screen. They may be retouched or subjected to special photographic procedures any way desired.

Some practical details of the procedure followed in the transmission of pictures by the apparatus described may serve to clarify the foregoing description. The picture to be transmitted is usually provided in the form of a negative, which is apt to be on glass and of any one of a number of sizes. From this a positive is made on a celluloid film of dimensions 5″x7″, which is then placed in the cylindrical film-holding frame at the sending end. Simultaneously an unexposed film is placed on the receiving end. Adjustments of current values for "light" and "dark" conditions are then made, over the line; after which the

FIG. 16—ELECTRICALLY TRANSMITTED FINGERPRINT.

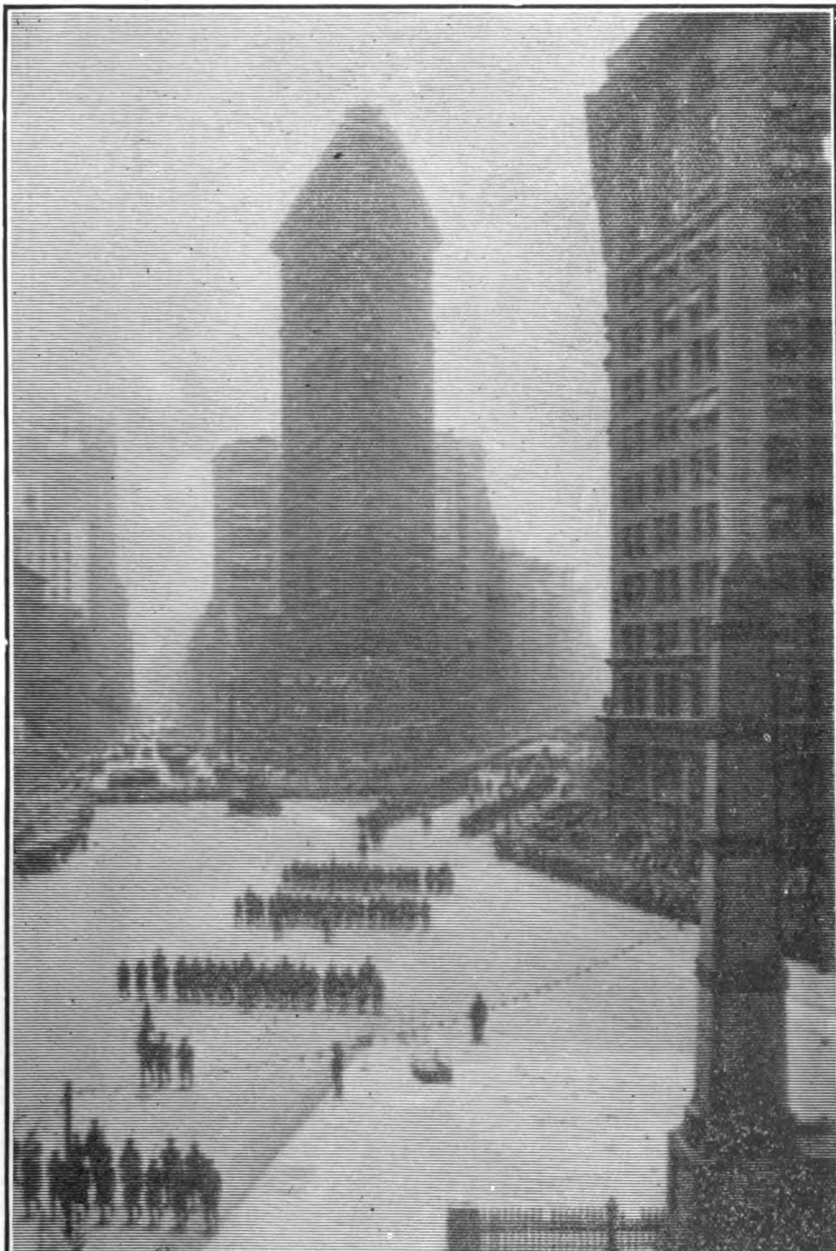

FIG. 17—PARADE ON 5TH AVENUE AS REPRODUCED IN CHICAGO EVENING PAPER OF SAME DATE.

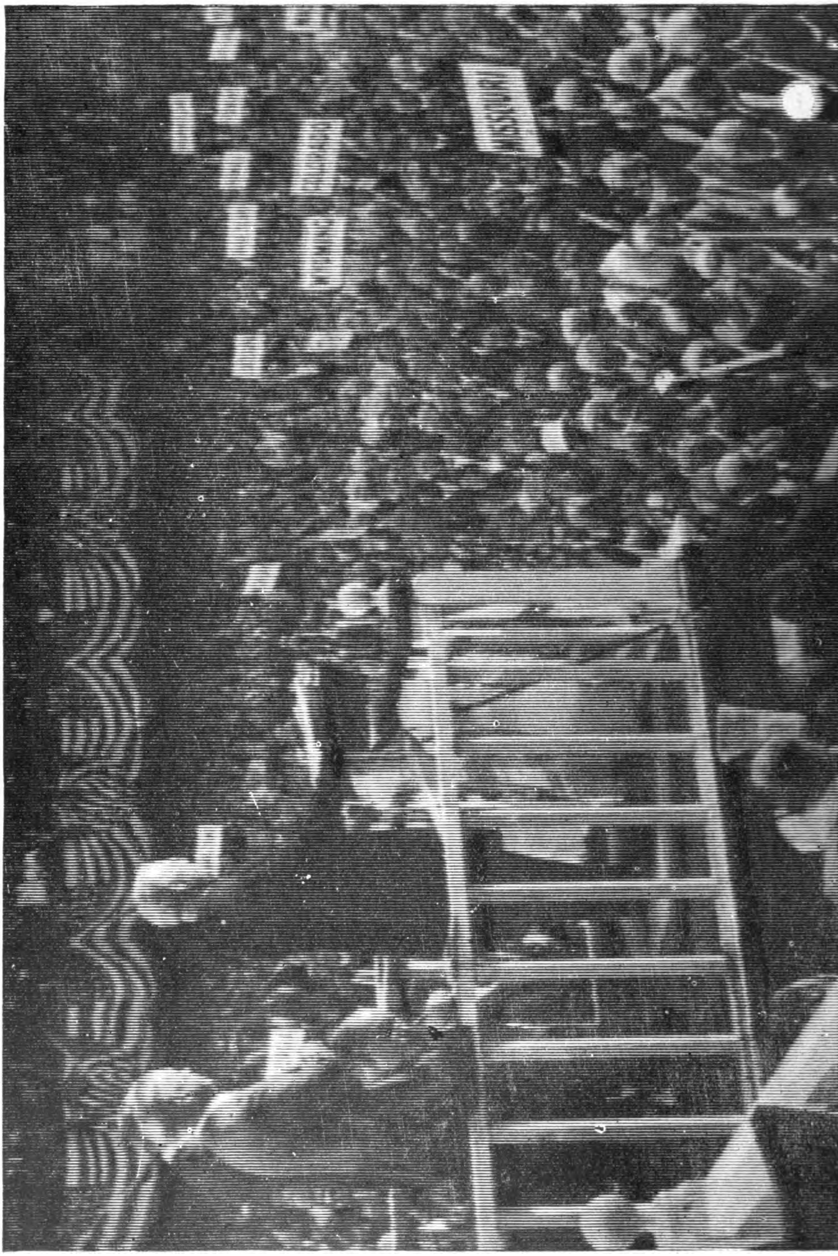

FIG. 18—OPENING OF DEMOCRATIC CONVENTION IN NEW YORK, SHOWN IN CHICAGO PAPERS ON SAME AFTERNOON.

two cylinders are simultaneously started by a signal from one end. The time of transmission of a 5″x7″ picture is, for a 100-line-to-the-inch picture, about seven minutes. This time is a relatively small part of the total time required from the taking of the picture until it is delivered in the form of a print. Most of this total time is used in the purely photographic operations. When these are reduced to a minimum by using the negative and the sending end positive while still wet, and making the prints in a projection camera without waiting for the received negative to dry, the overall time is of the order of three-quarters of an hour.

FIG. 19—PRESIDENT AND MRS. COOLIDGE LEAVING THE WHITE HOUSE, MARCH 4 1925. PICTURE TRANSMITTED SIMULTANEOUSLY TO NEW YORK, CHICAGO AND SAN FRANCISCO.

Fields of Usefulness

The fields in which electrically transmitted pictures may be of greatest service are those in which it is desired to transmit information which can only be conveyed effectively, or at all, by an appeal to vision. Illustrations of cases where an adequate verbal description is almost impossible, are portraits as, for instance, of criminals or missing individuals; drawings, such as details of mechanical parts, weather maps, Fig. 15, military maps, or other representations of transient conditions.

The value of electrically transmitted pictures in connection with police work has been recognized from the earliest days of experiments in the transmission of pictures. Besides the transmission of portraits of wanted individuals to distant points, there is now possible the transmission of finger prints. Some of the possibilities of the latter were demonstrated over the New York-Chicago picture sending circuit at the time of the Democratic Convention, July, 1924. The Police Department of New York selected the finger print of a criminal whose complete identification data were on file in the Police Department in Chicago. This single finger-print, together with a code description of the prints of all the fingers, was transmitted to Chicago and identified by the Chicago experts almost instantly. This method of identification it is thought, will be of value in those cases where difficulty is now experienced in holding a suspect long enough for

identification to be completed. Fig. 16 shows a transmitted fingerprint.

The fact that an electrically transmitted picture is a faithful copy of the original, offers a field of usefulness in connection with the transmission of original messages or documents in which the exact form is of significance, such as autograph letters, legal papers, signatures, etc. Messages in foreign languages, employing alphabets of forms not suited for telegraphic coding, are handled to advantage. It would appear that this method might under certain circumstances save many days of valuable legal time and the accumulation of interest on money held in abeyance. For these reasons, it is thought that bankers, accountants, lawyers, and large

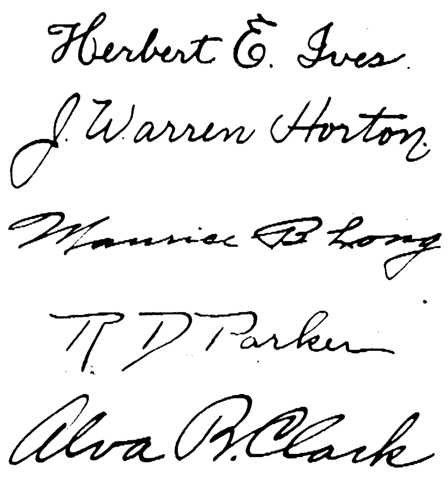

FIG. 20—TRANSMISSION OF HANDWRITING.

real estate dealers will find a service of this kind useful. Fig. 20 illustrates the transmission of handwriting.

Advertising material, particularly when in the form of special typography and drawings is often difficult and costly to get to distant publishers in time for certain issues of periodicals and magazines. A wire service promises to be of considerable value for this purpose.

A very large field for electrically transmitted pictures is, of course, the press. Their interest in the speedy transportation of pictures has been indicated in the past by the employment of special trains, aeroplanes, and other means for quickly conveying portraits and pictures of special events, to the large news distribution centers. The use of pictures by newspapers seems at present to be growing in favor, and many are now running daily picture pages as regular features.

Some of the possibilities in this direction were demonstrated by the picture news service furnished to newspapers, especially those in New York and Chicago, during the 1924 Republican and Democratic National Conventions at Cleveland and New York. During these conventions several hundred photographs were transmitted between Cleveland and New York and between New York and Chicago, and copies furnished the Press at the receiving points. Photographs made shortly after the opening sessions, usually about noon, were transmitted to New York and Chicago and reproduced in afternoon papers. Figs. 17 and 18 are examples of pictures which appeared in the Chicago papers of the opening events of the Democratic Convention in New York. (A demonstration of picture news service on a still larger scale, subsequent to the date of delivery of this lecture, was furnished on March 4, 1925 when pictures of the inauguration of President Coolidge were transmitted from Washington simultaneously to New York, Chicago and San Francisco; appearing in the afternoon papers in all three cities. One of the series giving a pictorial history of the inauguration is reproduced in Fig. 19.)

Other news-distribution agencies can also use electrically transmitted pictures to advantage. Among these are the services which make a specialty of displaying large photographs or half-tone reproductions in store windows and other prominent places. Electrically transmitted pictures of interesting events, about which newspapers have published stories, appear suited to this service, and have already been so used by some of these picture service companies. They may also be used as lantern slides for the display of news events of the day by projection either upon screens in front of newspaper offices or in motion picture theaters.

Protective Relays for Central Station Systems

By O. J. Bliss*

Presented May 18, 1925

This review gives some conception of the possibilities that may be attained by using relays in the protective apparatus of an electrical power distribution system. Mr. Bliss describes the different types and their uses and characteristics. The record of performance for the past four years shows a steady advance toward perfect operation that is encouraging.—Editor.

THE Standards of the A. I. E. E. define the Electric Protective Relay as "An intermediate device, equipped with contacts to open or close an auxiliary circuit, by means of which one circuit is indirectly controlled by a change in conditions in the same or other circuits." They are classified according to functions as—Directional, Power Directional, Polarity Directional, Phase Rotation, Current (either over current or under current), Voltage (either over or under) Power, Frequency, Temperature, Open Phase, and Differential. Thus any condition of a system may be used when it becomes abnormal to operate a relay and clear the system or to give a signal either audible or visual.

However, not all these types of relays are in general use on power systems, but many have some special application. On the other hand, we must include in our discussion not only protective relays, but also protective relay systems. In what I call a relay system the relay itself is simply a tripping, or contact closing device, which does not of itself respond to a change in conditions of the principal circuits, but is dependent on the scheme of connections.

Now that we have the definition of protective relays, it may be well to have an understanding regarding the thing to be protected. We often hear the expression that "Line number—is protected by—relays." This expression is inaccurate and, therefore, misleading. The primary function of protective relays as applied to a transmission system is to protect that system against abnormal conditions in some part of the system. If this is not done, then the whole system may become affected and a serious interruption of service or actual damage to some of the apparatus result. It is true a certain amount of protection is afforded a line by its relays in that the amount of damage due to a fault is limited. Especially in case of cable, a faulted line which is not promptly disconnected may be ruined by the heat generated. But this element of protection, altho desirable, is secondary in importance to the protection given to the system.

About the easiest thing in the world to do is to make a relay that will promptly disconnect a faulted member. In this respect there is no problem. The relay may be a simple solenoid and plunger with contacts but no time delay, or it may be more elaborate with bellows or clockwork to give some time delay. For years such simple relays have given good service, in fact so good that in many cases of cable failure the fault has been difficult to locate, and in some cases has healed so that, on test, the cable showed clear and was put back in service.

Systems Grow Complex

Notwithstanding all this, these simple relays became inadequate as systems grew in size and complexity. They were not discriminating. They would promptly disconnect a faulted member, but to obtain this result only, required the lines to be operated independently, with independent load, that is, they could not be operated in parallel or series or in a ring because fault current flowing over a good line in such a combination would cause its relays to trip as well as those on the faulted line.

It is highly desirable to operate a power system with lines in various combinations as just stated, for several reasons. There is a considerable saving in copper; better regulation; more flexibility and insurance against service interruptions. At least two lines may be run

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to the same center with common load so that a failure of one does not interrupt even a part of the load. To operate in this way without selective relays is practically impossible.

This brings us to the real problem—to make relays which will promptly disconnect a faulted line, but that will not trip due to fault current in a good line except in case of failure of the faulted line to clear, then the next line or lines in the combination should trip and limit the disturbance.

Ten or twelve years ago there were very few selective relays in service. There were some, but not many. Manufacturers were advertising and recommending certain relays for which selective action was claimed and their claims were honestly made. But they were mistaken. On laboratory tests these relays would operate satisfactorily, but when tried on a large power system, they failed consistently under certain conditions. The trouble was that in designing and in testing not all the conditions were taken into consideration.

Early Models Inadequate

Several of the large power companies including our local company were modifying relays then in service in order to obtain selective action, but without much success, and were also making tests with samples of new relays submitted by the manufacturers. Portions of the system were connected in a way desirable for normal operation, relays of various types installed and short circuits put on the system. Many of the tests resulted in failure of the relays, but enough data was obtained so that certain types were eliminated entirely. Changes were made in other types by the manufacturers and changes in the schemes of connections until satisfactory relays were developed.

This took place about ten or twelve years ago. Then, as fast as relays could be obtained and installed, it became possible to operate transmission systems with a very considerable saving in investment for copper, and better insurance against service interruptions. This came at a most opportune time as there was a great demand for copper for other purposes, during those years. Since then there have been no very radical changes, but a continuous development.

The most commonly used types of selective relays and relay systems at the present time are:

Over-current relays — induction type, inverse time with definite minimum time.

Power directional relays — induction type, inverse time with definite minimum time.

Pilot-wire relay systems — balanced voltage.

Pilot-wire relay systems—balanced current.

Split conductor cable.

Over-Current Relays

Over-current relays are generally of the induction type quite similar in construction to the induction type watthour meter; except that the driving torque is produced by current only rather than by current and voltage coils. Counter torque is provided by a spiral spring. When sufficient current flows through the relay winding to produce the necessary torque, the disc rotates until the contacts close, thereby completing the trip circuit.

These relays have an inverse time characteristic with definite minimum time—this is, the greater the current value, the shorter the time within certain limits. For current values above a certain amount, the time is constant or definite. Both the current settings and the time settings are adjustable so that selective action may be obtained between different relays.

This type of relay is a most reliable device, capable of very fine adjustment and having very good permanence of adjustment. On a 60-cycle circuit a relay with a two-second minimum time setting will repeat on successive tests within one cycle or 1/60 of one second.

Power Directional Relays

Relays dependent on current alone for their operation will function if sufficient current is flowing regardless of the direction of power flow. It is desirable in a great many cases, and necessary in some, to have protective relays which will trip only when the power flow is in a certain direction.

Power directional relays have been developed to fill this requirement. Essen-

tially they are combinations of over-current relays and a wattmeter or power directional element, each element having its own trip contacts, but the trips of both connected in series. The over-current element may be an induction type or a solenoid type, although the induction type is necessary if selective action is to be obtained.

One manufacturer combines an over-current element and a watt-meter element in one case making a single-phase relay. Three of these units are then necessary for a three-phase line. Another manufacturer mounts the wattmeter elements for the three phases in one case using three separate over-current relays, one in each phase in series with the wattmeter element.

The power directional element is a very sensitive wattmeter. Its coils must be wound for normal voltage of the system, but it must operate in cases of trouble at 1% or less of normal voltage.

Pilot-Wire or Balanced Systems

The basis of pilot-wire or balanced protection is that the same current will flow at both ends of a line if no fault exists in that line, but that unequal currents or currents in opposite directions will flow if any kind of fault is present. The requirements of a pilot-wire scheme are that it shall operate to trip the breakers at both ends of a line in the event of a fault in that line, but that it shall not trip for faults in other parts of the system even though fault current passes through the pilot-wire section.

Pilot-wire schemes are usually some form of balanced voltage or balanced current arrangement. In the balanced-voltage system the secondaries of the line-current transformers are connected in opposition through the pilot wires so that normally no current will flow in the pilot-wire circuit. In case of a fault this balance is destroyed, current flows in the pilot wires, and the relay which is in the pilot-wire circuit, trips. This relay is instantaneous and may be a simple solenoid type or induction type. The line-current transformers for this system are special and must have identical characteristics both for normal current values and for short-circuit current values, otherwise the condition of balance under through fault conditions will not be maintained.

This method of protection, although quite extensively used in England, has not met with much favor in this country.

In the balanced-current system the secondaries of the line-current transformers are connected in series instead of in opposition as in the balanced-voltage system. Under normal conditions, current circulates in the pilot circuit, but there is partial or complete opposition in case of fault. Tripping of the relay is accomplished by a number of various forms or modifications in the system. Here in Chicago we have a balanced-current system which has proved very satisfactory, in fact we have two forms of the same system; one form with which about 170 lines are equipped, requires but two pilot wires, and one relay at each end of the line. This system is a protection against grounds only, but as nearly all cable faults start from phase to ground, practically 100% protection is obtained. The other form of this system requires three pilot wires and three relays at each end of the line, but affords protection against all classes of faults. For both forms a very simple solenoid-type differential relay is used and ordinary current transformers on the lines.

Split Conductor System

This system of protection depends upon a special type of cable having two conductors for each phase or six conductors for a three-phase cable, all insulated from each other. Under normal conditions the currents in the two conductors of each phase are approximately equal, and may be balanced against each other. Under fault condition this balance is destroyed and tripping accomplished. Besides the special cable, other special equipment is necessary for example, to provide for clearing and faults. It will be seen that if a fault occurs very near one end of the line, the currents from the remote end in the two conductors of any phase may still be equal and, therefore, a failure to clear may result. This may be obviated by installing end reactors or a three point switch.

The induction type relays, both over-current and power-directional are by far the most common or most generally

used; the type is almost universal. Balanced systems are not so common, but where used have given very good results. The balanced-voltage system is extensively used in England; here in Chicago we are using a balanced-current scheme with a differential relay and various forms of balanced systems are used to a limited extent in other places. Split conductor cable is used to quite an extent in Boston and in far-off Melbourne, Australia.

Other Types

However, these four systems which I have briefly described do not by any means exhaust the list of protective relays. There are many modifications and combinations of them and there are many others not in such general use, but having some special application.

For example, two or more lines operating in parallel may be balanced against each other somewhat in the same way that the two conductors of a phase in a split-conductor cable are balanced against each other. In balancing separate cables the relays may be nondiscriminating, that is in case of failure of one cable, both will be disconnected, or they may be discriminating so only the faulted cable is disconnected.

A quite common application of relays is for protection against ground only. This can be accomplished in a number of ways. A cable-sheath transformer may be used with its winding connected to a relay. When slipped over the cable the three phase conductors form the primary of the relay transformer. Normally the three currents produce no flux in the core of the sheath transformer, but in case of a ground the three primary currents no longer neutralize, therefore, magnetic flux is induced in the core and current flows in the secondary winding and relay.

Induction type relays may be used as ground relays by connecting one relay in the common neutral of the three line current transformer secondaries. Selective action may be obtained between ground relays on different lines in the same way as is done with the phase relays, but much lighter settings may be used.

Certain lines of an ungrounded system may be disconnected in case of ground by the use of grounding transformers, that is, three transformers with primaries connected to the three phases of the line in start with neutral grounded, and with secondaries connected in delta with a relay in circuit.

A new type of relay has recently been put on the market called an impedance or distance relay. It is really a combination in one relay of an over-current relay, and an under-voltage relay. The under-voltage element is in a way a restraining element which prevents the contacts from closing within a specified time unless a certain relation of heavy current and low voltage exists. Under short-circuit conditions the voltage will be lowest near the point of short circuit, therefore, the time element of the nearest relay will be the shortest and this relay will trip. Selective action is thus obtained.

Used for Station Apparatus

Many of the types of relays described are also used on station and substation apparatus, as well as others which are modifications of these types. Turbo-generators are not protected against overload, they are provided with relays to trip their oil breakers in case of internal trouble. One of the most common and best systems is the differential, similar to that used on lines. Current transformers are installed in both ends of each phase winding with their secondaries in series and having an instantaneous relay connected across the secondary leads at two equal-potential points. Normally, current circulates in the current transformer secondaries and connecting leads, but not through the relay. In case of fault in the generator winding, the balance between the secondary currents is destroyed and current flows through the relay.

Generators are sometimes equipped with over-current relays to give a signal in case of overload, but not to trip. I believe the English practice is to install over-current relays with a setting higher than the short-circuit current of the machine but low enough to trip in case of back feed from other machines.

Synchronous converters and transformers are usually equipped with over-current relays either with or without time

delay. The current settings vary from 200% to 500% full load, depending on local conditions.

Transformers are frequently equipped, in addition, with differential relays with trips so connected that both primary and secondary coil breakers are opened in case of internal fault. This type of relay may be two coils acting on a single core for each phase, one coil connected to the secondary of a primary current transformer, the other to a secondary current transformer.

In addition there are many other relays for special purposes or determined by local conditions. This list includes balanced-current relays, reverse-current relays, speed-limit relays, temperature relays, etc.

Comparison of Types

Each of these various types of protective relays and relay systems has advantages and disadvantages. The most universal of them all, the induction-type over-current and power directional, as good as they are, have limitations and objectionable features. The proper settings are many times difficult to work out. Sometimes it may even be impossible to make all relays in a combination of lines, selective. The number of relays which may be made selective with one another is limited by the maximum time allowable for the longest setting. This time is usually less than two seconds. The time element itself is objectionable, especially so for a cable system. In the beginning of this paper, it was stated that the old solenoid relays would sometimes disconnect a line so promptly that the fault was quite limited in extent and might even heal. This does not happen with time-element relays. The burns may be quite extensive. On the other hand these relays are reliable, and will do what they are designed to do with a very small percentage of failures.

The application of balanced systems is limited to comparatively short lines by the cost of pilot conductor. The relay settings can, however, be made low, without time delay, so that faults are cleared promptly with very little disturbance to the system.

The split-conductor cable system has the same advantages as regards sensitiveness, or low current values to trip, and no time delay, as the balanced system. Its disadvantages are the cost of special cable and cost of joints and other special apparatus necessary.

From this description of selective relays, it may be assumed that the protection of a large central station system is fairly simple. Such is not the case. The principles involved are fairly simple, but the difficulties encountered in the application to a system with many substations and industrial transformer vaults, a network of transmission lines, several generating stations and then this whole system tied to one or more other large systems, are almost infinite. The methods of operating must also be considered and the fact that some lines may be temporarily out of service. The time of the longest setting must be kept down to a certain maximum value, say less than two seconds. Some relays are suitable for particular installations and unsuitable for others. Again two different types of relays may be installed on the same line, for example power directional relays and balanced relays. Then again, it may be necessary to interlock relays so that one is inoperative unless a certain other relay closes.

Record of Performance

Notwithstanding these difficulties, most large companies are obtaining very good results from their selective relays. It may be of interest to have some actual figures on performance on our local system.

In 1921—292 total operations 94% correct.

1922—620 total operations 95.5% correct.
1923—699 total operations 96.3% correct.
1924—767 total operations 97.9% correct.
1925—(to May 11)—226 total operations 99% correct.

which I think is a very good record. The failures may result from defects in the relays or from a miscalculation in determining the proper setting, or from not having proper information on operating conditions. The small percentage of failures shows that the relays are most reliable devices and that the settings have been well worked out.

Every case of failure is thoroughly investigated and the cause determined in

order that similar cases may be avoided. This analysis of failures is a most interesting problem, but is also full of difficulties, one of which is to get complete, correct, data. Whether the correct solution is obtained depends upon the data; if incomplete or incorrect we arrive at a certain conclusion correct for these data although perhaps actually incorrect. In all such cases the relays are immediately tested. If they are found in good condition, then the investigation must be carried further. Occasionally a case will be extremely baffling, even mysterious, but there are no mysteries, the case might be simple if all the information were available. We had a case of apparent failure about two years ago resulting in a service interruption at an industrial transformer vault. The relays were tested and found o. k. Then we went after information regarding all the conditions, but after this was all in, it did not explain the case. In fact, when this information came to me, it could mean only one thing, and that was that there had been no trouble and no service interruption. So we went after more information until finally we found a night operator who told us a certain switch was open at the time. Apparently only this one man knew that particular switch was open. So the trouble was explained, but there was no failure of relays.

My experience has given me a great deal of confidence in present day selective relays. If installed according to the manufacturers' directions and the settings properly made, they will function as designed, which brings us to another phase of the subject.

From the percentages of correct operations already given, one might assume that we now have nearly perfect relays and that there was nothing more to do. They are nearly perfect in operation or in functioning as designed. But there is still much to do. Some of the objectionable features of each have been stated. Relays will be developed without these objectionable features; more than this, relays may be developed which will anticipate the fault and still more than this, methods may be developed by which it will be possible to determine beforehand whether a fault is likely to develop in a cable. These are not dreams, they are opportunities; some results along all these lines have already been attained.

The subject of protective relays is one which has been given a great deal of attention during the last few years. Many of the large operating companies have made modifications of standard protective systems as well as experimenting and developing special schemes adapted to their own peculiar conditions. The American Institute of Electrical Engineers has a relay committee, of which I am a member. This committee has collected, analyzed and classified much data on standard apparatus and on experimental or trial schemes. Reports of the committee have been published, and the original data is also available.

There is, of course, a reason for all this activity, it might even be called, competition between the operating companies. Each is endeavoring to secure the very best possible results from present relays and to develop something more nearly ideal. I have already stated some of the reasons why selective relays were necessary; economy in investment for copper, better regulation, flexibility and freedom from service interruptions. All of these directly benefit the customer either though lower prices or better service.

The real reason for protective relay is —Service—

Today, service to the customer is the first consideration of the Central Station company, and the use of protective relays is one of the means for giving better service. Today we find the central station companies determined not only to give the best service the state of the art will allow, but continually to improve the state of the art.

The Western Avenue Pumping Station

By L. D. Gayton*, M. W. S. E.

Presented December 29, 1924

Careful attention to economy and reliability of operation and the studies of different power producing systems mark this design of the world's largest waterworks pumping plant. Detailed costs of designs based on five different prime movers are given. Selection of auxilliaries was based on a carefully calculated heat balance. Mr. Gayton describes the factors controlling the designs adopted and shows how they were carried out.—Editor.

THE latest addition to the Chicago Water Supply System will be called Western Avenue Pumping Station and will be located at Western Avenue and 50th Street.

This will be a steam station and will have an installed pumping capacity of 300 m. g. d. The main pumps will be centrifugals driven through gears by compound steam turbines with steam at 300 lb. gauge pressure and 200 deg. F. superheat.

The first recommendation that this station be built was made by John Ericson, City Engineer, in 1911. In 1915 a study of the entire district south of Madison Street was made, and it was then again recommended that this station be built and that it be located at or near Western Avenue and 55th Street. In January, 1922, a report was made to the City Engineer by the Water Pipe Extension Division, in which report the following appears:

"A large area in the south west part of the City is constantly without sufficient pressure, and it is necessary to operate a booster station at 63rd Street and Kostner Avenue, which supplies the so called Clearing District in the vicinity of 63rd Street and Central Avenue. Many complaints of low pressure are received from the zone bounded by 35th Street and 55th Street, and extending across the entire city. This area contains the Stock Yards. The Yards requirements for a number of years past have reached a maximum rate of over 50 m. g. d. This great demand has to be met in a low pressure zone and it adds greatly to the difficulty of maintaining service pressure in the vicinity of the Yards."

The foregoing shows further reasons for building this station and for its location. It also shows that the City Engineer's judgement as to the need of this station and as to its specific location was correct when made in 1911.

Actual construction of the station was started about September 1, 1924 and is now in progress.

Area to be Supplied

The new station will supply a territory which is now supplied jointly by the 68th Street, Roseland, Central Park and 22nd Street Pumping Stations, thus relieving all these stations of part of their load and thereby improving the service in their respective reduced districts. Under a system of very limited metering such as at present exists, the territory to be supplied by this new station will cover about nineteen square miles, bounded on the north by 35th Street, south by 61st Street, east by State Street and west by Cicero Avenue. If universal metering is adopted, the station will be able to serve double the above area. The distribution system has been designed to serve either area eventually.

Source of Water Supply

The station will obtain its water supply from the Edward F. Dunne Crib through the Southwest Lake and Land Tunnel completed in 1910, and which now supplies the 68th Street and Roseland Pumping Stations. A 12-ft. extension of this tunnel has been constructed in 73rd Street to Western Avenue and north in Western Avenue to the new pumping station at 50th Street. A connection with the older tunnel was made at State and 73rd Streets, where a branch tunnel leads off to Roseland

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Pumping Station, and where provision had previously been made for the Western Avenue Extension.

At the station a 12-ft. lateral extends from the main tunnel to a gate shaft at the east curb line of Western Boulevard. From this gate shaft two 10-ft. tunnels extend, each to screen shafts at the north and south ends of the station and connected by a suction tunnel under the pump room. A concrete bulkhead divides the suction tunnel into two sections. Each section serves two pumps. By closing the gate in the gate shaft, either half of the suction tunnel, including one screen shaft, may be isolated and pumped out for inspection, cleaning or repairs.

Loss of Head in Tunnel System

The pumping capacity of the station and the head against which it must operate, are based upon curves carefully determined by the Water Pipe Extension Division.

The maximum flow conditions in the Southwest Lake and Land Tunnel were assumed as follows:—

165 m.g.d. to the 68th St. Pumping Station
88 " " " Roseland " "
5 " " " South Park System (which obtains its supply from this tunnel), to the Western Avenue Station.

This flow will give an estimated loss of head of 19.9 feet between the Edward F. Dunne Crib and the new station. If we assume the lake level as —2. then the water in the suction tunnel will be at —21.9 under the above conditions of flow. The center line of the pump shafts will be at — 11, so, if we assume a friction loss of three feet through the pump suction, the maximum suction lift on the pumps will be 13.9 feet. This is considered conservative designing so as to minimize the danger of cavitation. With this suction lift, and with reasonable velocities, the pumps should operate at highest efficiencies. The pumps will be set at — 11; the elevation of the curb is + 13.8, and the maximum head required in the discharge system, including friction loss, will be 107 feet. This gives a total head of about 145 feet against which the pumps must operate.

Mr. Paul Lippert, Engineer of Pumping Station Efficiency, made a very careful and complete survey of the Southwest Tunnel System in order to arrive at a proper value of *n* to use in Kutter's formula in calculating the loss of head. This survey gave higher values of *n* than are usually assumed, and we used these high values in our calculation.

Selection of Equipment

With reference to the Station itself, it may be well to note the controlling factors which must be considered in the design of such a plant.

Continuous operation is the first and foremost requisite. The very life of a municipality depends upon its water supply. The pumping stations must operate day and night, week in and week out, without fail, so reliability of operation is the prime factor in the selection of all equipment and in the entire installation. After this, economy of operation is to be considered.

Before deciding upon the type of equipment for the station, complete designs were drawn and estimates of cost made of pumping stations, with the following prime movers; steam turbine-driven centrifugal pumps; triple-expansion pumping engines; Diesel engines direct-connected to centrifugal pumps; 2300-volt motors direct-connected to centrifugal pumps and 12000-volt motors direct connected to centrifugal pumps.

Comparisons were also made of the cost of producing steam with coal-burning stokers, with fuel oil and with powdered coal. In making these comparisons, we worked in conjunction with representative manufacturers in each line, and used their figures as to the cost of equipment and their guarantees as to operating economy.

These studies, including preliminary designs and tabulation of all data and results, indicated that, for our conditions, the relative value, as regards economical operation of the different prime movers considered, was as follows:—

1st—Turbine-driven centrifugals.

2nd—Diesel-driven centrifugals.

3rd—12000-volt motor-driven centrifugals.

4th—2300-volt motor-driven centrifugals.

5th—Triple-expansion pumping engines.

The fuel studies indicated that, with

PROPOSED MUNICIPAL PUMPING STATION

COMPARATIVE ESTIMATED COSTS OF COMPLETE STATION

Costs based on 300 million gallons per day for 300 days per year (which is equal to 90,000 million gallons per year) against a total head of 150 feet.

GENERAL DATA	Type of Prime Mover	STEAM TURBINE Steam Press. 300# ga. Superheat 200° F. Abs back Press. 1"	TRIPLE EXPANSION ENG. Steam Press. 200# ga. Superheat 100° F. Abs back Press. 2"	DIESEL OIL ENGINE 6 cylinder, 2 cycle	ELECTRIC MOTOR 2300 VOLTS	ELECTRIC MOTOR 12,000 VOLTS
	Type of Pump	Centrifugal single stage	Plunger Pump	Centrifugal 4 stage	Centrifugal Single stage	Centrifugal Single stage
	Capacity of Pump	60 million gals. per 24 hrs.	50 million gals. per 24 hrs.	60 million gals. per 24 hrs.	60 million gals. per 24 hrs.	60 million gals per 24 hrs.
	Water H.P. of Pump	1590	1315	1590	1590	1590
	Engine H.P.	1900 brake	1390 Indicated	1900 brake	1900 brake	1900 brake
	Mechanical Eff. of Unit	Pump - 83½%	94½%	Pump - 83½%	Pump - 83½% Motor - 94%	Pump - 83½% Motor - 94%
	Actual Thermal Efficiency of Unit	18%	21.8%	23.7%		
	Steam or Oil Consumption. Lbs. per water H.P. hour	11.45	9.66	565		
	Steam or Oil Consumption. Lbs. per engine H.P. hour	9.55 per brake H.P.	9.15 per indicated H.P.	.473 per brake H.P.		
	Electric Power Consumption. Kilowatt-hrs. per million ft.-gals.				4.75	4.655
	Boiler Horsepower Reqd.	4,060 5 units in operation	3200 6 units in operation			
	Duty - million ft.-lbs. of Work per thousand lbs. Steam	173	205			
	Duty - million ft.-lbs. of Work per million B.T.U.	130	162.8	184		
	Fuel or Power - for 300 days	61,200 tons of Coal 5 units in operation	48,240 tons of Coal 6 units in operation	4,752,000 gals. Fuel Oil 5 units in operation	64,125,000 K W Hrs. 5 units in operation	62,842,500 K W Hrs. 5 units in operation
ORIGINAL INVESTMENT	Cost of Land	$52,072	$58,748	$32,550	$23,400	$20,900
	Cost of Buildings	933,350	1,154,250	656,800	455,000	420,000
	Cost of Equipment	1,201,400	2,423,858	1,716,495	352,500	342,900
	Miscellaneous	18,000	20,000	66,000 Fuel Oil Tank	20,000	20,000
	Total Investment	$2,204,822	$3,656,856	$2,471,845	$850,000	$803,800
OPERATING COSTS - PER YEAR	Cost of Labor	$63,495	$89,437	$30,000	$25,680	$25,680
	Cost of Fuel - Coal $4.00 per ton, Oil $0.05 - gal.	244,800	190,944	237,600		
	Cost of Power $0.0064 per kilowatt hour				413,904	408,132
	Cost of Oil, Waste, etc.	3,000	15,300	20,000	5,000	4,000
	Repairs & Maintenance	22,624	40,616	13,700	5,280	5,144
	Interest on Investment and Depreciation	136,600	201,700	179,385	69,200	65,735
	Total Operating Cost	$470,519	$537,997	$480,685	$519,064	$508,691
UNIT COSTS	Unit Cost of Labor per million gallons	$0.71	$1.00	$0.33	$0.285	$0.285
	Unit Cost of Fuel or Power per million gals.	2.72	2.12	2.64	4.60	4.535
	Unit Cost of Oil, Waste, etc. per million gals.	0.03	0.17	0.22	0.056	0.044
	Unit Cost of - Repairs and Maintenance per million gals.	0.25	0.45	0.15	0.06	0.057
	Unit Cost of - Interest on Invest. & Depreciation per million gals.	1.52	2.24	2.00	0.77	0.73
	Total Cost of pumping one million gallons	$5.23	$5.98	$5.34	$5.77	$5.65
	Total Cost of pumping one million gallons one foot high	$0.0349	$0.04	$0.0356	$0.0385	$0.0377

our conditions, steam could be produced about as cheaply with either stokers or powdered coal, and that steam from fuel oil would cost 50% more than from either of the first mentioned methods.

The turbine and Diesel plants were practically on a par. The high power charge, as well as reliability of service, are the controlling factors in the electric-driven plant, and the high first cost and the comparatively small capacity units are the controlling factors in the triple-expansion plant.

As regards reliability of operation, either the turbine or triples would be acceptable; the 2300-volt motors are somewhat less dependable; neither the 12000-volt motors or Diesel engines have been used in large pumping installations long enough to warrant their acceptance without question.

Our final analysis indicated that, for our conditions, the selection of steam, turbine-driven, geared, centrifugal pumps, with boilers fired by forced-draft underfeed stokers, would give us a plant that

PROPOSED MUNICIPAL PUMPING STATION
COMPARATIVE ESTIMATED COSTS OF COMPLETE STATION

Costs based on an estimated hourly load curve for 24 hours per day, which gives a daily pumpage of 153 Million Gallons and a pumpage of 55,850 million gallons per year of 365 days

	Type of Prime Mover	STEAM TURBINE Steam Press 300# ga. 200°F Superheat 1.5# abs back press	ELECTRIC MOTOR 2300 Volts	Remarks
GENERAL DATA	Type of Pump	Centrifugal single stage	Centrifugal single stage	
	Capacity of Pump	50 to 75 M.G.D.	50 to 75 M.G.D.	
	Water H.P. of Pump	905 to 1840 (min. to max. reqd.)	905 to 1840 (min. to max. reqd.)	
	Engine H.P.	1080 to 2150 (min. to max. reqd.)		
	Mechanical Efficiency of Unit	Pump-84 to 85.5% 85% aver.	Pump-84 to 85.5% 85% aver.	
	Actual Thermal Efficiency of Unit	17.75% average		
	Steam Consumption - Lbs. per water H.P. hour	10.5 to 12.8 Lbs. 11.35 Lbs. average		
	Steam Consumption - Lbs. per engine H.P. hour	9.0 to 10.75 Lbs. 9.63 Lbs. average		
	Electric Power Consumption - Kilowatt-hrs. per million ft-gals.		Entire Plant 4.08 K.W.Hr.	
	Boiler Horsepower required	Entire Plant 960 to 2405		
	Duty - million ft-lbs. of work per thousand lbs. of Steam	154 to 188 174.4 average		
	Duty million ft-lbs. of work per million B.T.U.	118 to 142 132 average		
	Coal or Power - for 365 days	Entire Plant 28,400 tons	Entire Plant 28,169,000 K.W.Hrs.	
ORIGINAL INVESTMENT	Cost of Land	$203,000	$67,000	
	Cost of Buildings	1,341,315	836,670	
	Cost of Equipment	1,083,300	669,500	
	Miscellaneous	131,380	78,658	
	Total Investment	$2,758,935	$1,651,828	
OPERATING COSTS PER YEAR	Cost of Labor	$78,342	$50,322	
	Cost of Coal @ $3.00 per ton	85,200		
	Cost of Power @ $.00833 per Kilowatt hour		233,080	
	Cost of Oil, Waste, etc.	5,000	5,000	
	Repairs and Maintenance	21,807	12,100	
	Interest on Investment and Depreciation	178,400	118,857	
	Total Operating Cost	$368,749	$413,359	
UNIT COSTS	Unit Cost of Labor per million gallons	$1 40	$ 90	
	Unit Cost of Fuel or Power per million gals.	1 52	4 17	
	Unit Cost of Oil, Waste, etc., per million gals.	09	·03	
	Unit Cost of Repairs and Maintenance per million gals.	40	22	
	Unit Cost of Interest on Invest. and Depreciation per million gals.	3 19	2 12	
	Total Cost of Pumping one million Gallons	$6 60	$7 50	
	Total Cost of Pumping one million gallons one foot high	$0 053	$0 061	

would rate highest as regards reliability and lowest operating cost. Therefore, these were selected.

Railroad Facilities

The Station will be served by a siding from the Grand Trunk Railway. One spur will extend over a 150-ton track scale, and over a 60-ton track hopper. The other spur will extend south and serve a large coal storage space back of the Station. The siding will be carried on a concrete trestle. The crossing of Oakley Avenue made necessary a rather complicated plate girder bridge.

Coal Handling System

The incoming coal is dumped from the cars into the 60-ton track hopper. The track hopper discharges onto an apron conveyor, which carries the coal to the crusher from which it is discharged into

a pivoted-bucket conveyor which conveys the coal to the 600-ton-capacity overhead bunkers. From the overhead bunkers the coal passes into a 2-ton weigh larry and then on to the stokers.

This system places the bunkers outside the boiler room where there is less chance for fires in the coal from spontaneous combustion and it enables us to weigh all the coal going to the stokers. The overhead bunkers give about seven days storage of coal.

Ash Handling System

The ash handling system is simple and direct. Each boiler has a hopper of 8 tons ash capacity. From the ash hopper a manually-operated car takes the ashes to a skip-hoist which elevates them to a 60-ton overhead ash bunker. From this bunker it may be spouted either into trucks or into railroad cars. The entire system is so proportioned that all ashes can be removed by the day shift.

Boilers

There will be four 600-h. p. Edgemoor boilers installed, each equipped with an integral Foster superheater. These boilers will operate under normal conditions from 100 to 175 per cent of rating. Ordinarily three boilers working at 175 per cent of rating will carry the maximum load, leaving one boiler in reserve. In case of an emergency, with two boilers out of service, the remaining two boilers will carry the peak load at 210 per cent of rating.

The boilers will be served by four Taylor underfeed stokers of the latest design. The forced draft is supplied by four Sturtevant Turbovane fans. Both stokers and fans are designed to carry the peak loads with a good factor of safety. Each stoker has its individual air duct, so there is no chance for lost pressure through cross connections.

The maximum steam demand will be about 75,000 lb, per hour, and the boilers will generate this at 315 lb. gage pressure and 225° F. superheat.

In order to arrive at the proper size of boiler to use, studies were made of 500, 600, 700, 800 and 1000-h. p. units. It was found that four 600-h. p. boilers gave the best operating conditions as this size gave us the proper number for reserve, gave operating rates in the range of best efficiency, and a comparatively small percentage of banking hours.

The boilers will be served by a radial brick stack extending 217 feet above the boiler room floor. The maximum load on the stack will be when two boilers on one side are operating at 210 per cent of rating and the stack is designed to carry this load. The shaft is designed to withstand a wind pressure of 22 lbs. per square foot on the projected diameter with no tension on the windward side. The stack will be protected by lightning rods which will be grounded to a 48-inch water main.

Main Pumping Units

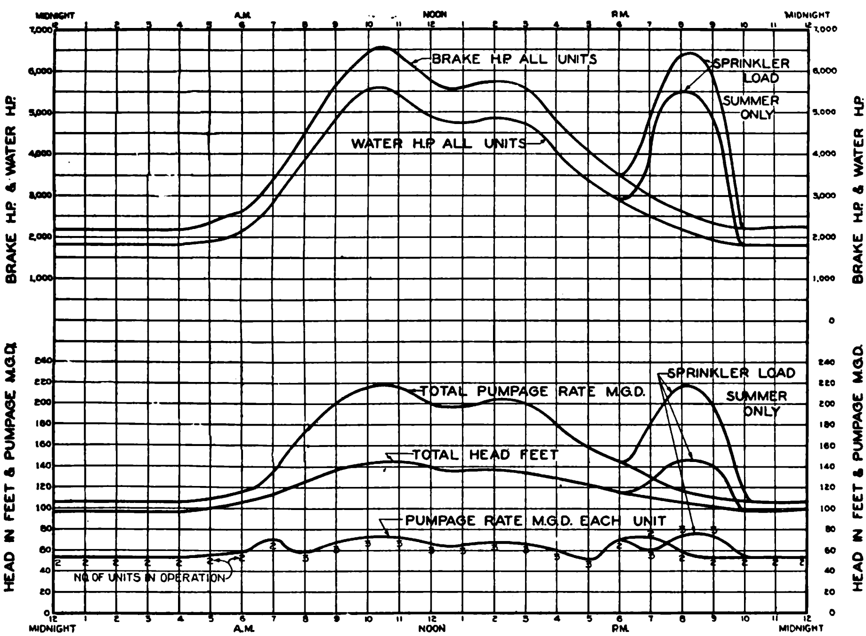
The main pumping equipment will consist of four centrifugal pumps driven through gears by compound steam turbines, all built by the De Laval Steam Turbine Company. These pumps are designed to deliver from 50 to 75 m. g. d. against a total head of 150 feet. Three pumps will carry the entire station peak load, leaving one unit in reserve. It is possible to vary the speed of the units so as to follow the desired load very closely, and thereby secure economical operation at all times.

The remarkable advance made in the design of this type of equipment in the last few years will be appreciated when we note that at the point of maximum efficiency these turbine units have a guaranteed water rate of 8 lb. per brake horsepower or 9.6 lb. per water horsepower. This expressed as duty give 203,-500,000 foot-pounds of work per 1000 lb. of steam.

The circulating pump is on an extension of the main pump shaft, thus securing the same low water rate as the main unit. The surface condenser which is directly under the low pressure barrel of the turbine is served by a rado-jet air pump and a centrifugal condensate pump, all made by the Wheeler Condenser & Engineering Company.

Discharge System

The discharge from each unit will pass through an individual Venturi meter into a duplex header system in the pipe vault. In this vault a system of motor-operated gate valves, controlled from the floor of



LOADS ON MAIN PUMPING UNITS
FOR
WESTERN AVE PUMPING STATION

the pump room, will enable the operator to cut in or out the discharge of any one unit, to isolate one entire header for repairs, or to send the entire capacity of the station into any one of the four discharge mains from the station. In case of a fire in the Stock Yards or the lumber districts the system could be operated to throw a tremendous amount of water at high pressure into those districts.

All pipes and fittings have been especially designed for a maximum pressure of 186 lb. per sq. inch and with a limiting stress of 3000 lb. tension in the cast iron.

Auxiliaries

After deciding upon the type of pumping equipment and boilers the next step was to study the auxiliary equipment, and to this end three different methods of driving and auxiliaries were considered: all motor drive, all steam drive, and a combination of the two. It was found that a scheme, wherein all the auxiliaries were driven by electric power furnished by a D. C. generator driven by a non-condensing steam turbine, adapted itself to the station heat balance and therefore gave the greatest economy. The stokers, fans, boiler feed pumps, etc. will therefore be driven by direct-current electric motors. This power will be furnished by either one of duplicate turbine-driven generators. There will be two motor-driven and one turbine-driven boiler feed pumps, either one of which will carry the entire peak load.

Practically all the auxiliaries will be installed in a separate room between the boiler and pump rooms. Indicating and recording instruments will be placed in this room so that one man will have the entire steam generating operation under his control.

Feed Water System

It is well known that Lake Michigan water is reasonably good for boilers as it contains only small percentages of scale forming minerals. However in the Western Ave. Pumping Station the desire for continuous high boiler efficiency led to the use of an evaporator plant, for distilling all make-up water to be sup-

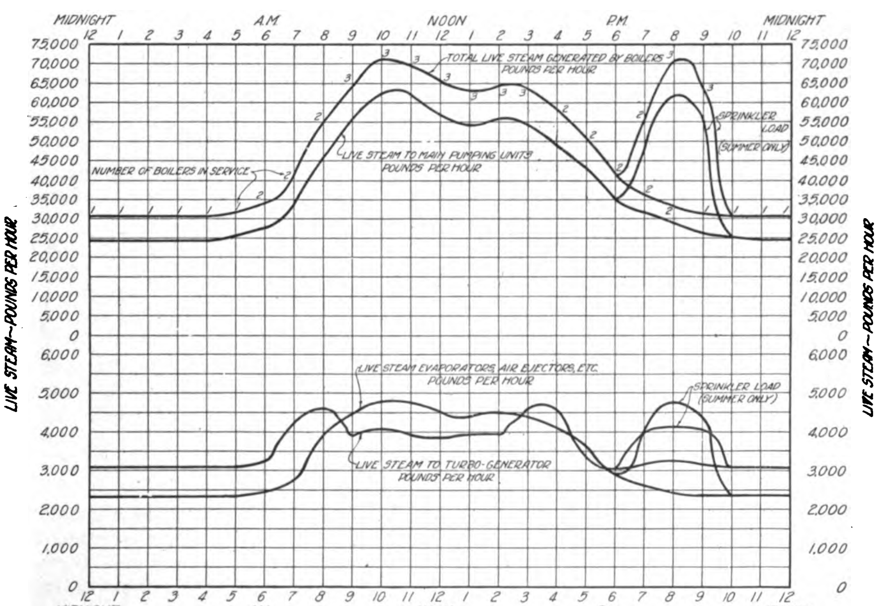
plied to the boilers. The small amount of make-up required in the station allows the use of a small evaporator, which justifies it from an investment standpoint. Three very desirable results are secured by its use; first, a supply of distilled water for boiler use; second, an elimination of all boiler blowdown except at long intervals; and third, a higher average boiler efficiency than would otherwise be obtained.

Aside from the evaporator plant and the very high pressure required from the boiler feed pumps the system is not unusual. A brief outline of the method of boiler feeding and water treatment will bring out the conditions which must be met, and how they have been accomplished.

Broadly speaking all the steam which leaves the boilers is returned as water. The only make-up required is to replace that which is lost from the system, thru vents, drains, leakage and from safety and relief valves. This is not expected to amount to more than three percent of the total output of the boilers during normal operation, although the evaporators and equipment in the make-up system will take care of seven and one-half percent make-up if necessary.

Another important fact, which vitally concerns the feed water system is the absence of oil in any of the condensate or exhaust steam which returns to the boilers. With steam turbine driven main units, and turbine and motor driven auxiliary equipment, even the oil separators may be eliminated from the pipe lines, without fear of the ill effects of oil in the system.

The logical place to start tracing the feed water system seems to be at the raw make-up water connection which is made to a small open feed water heater. This heater, or evaporator preheater as it is called serves three important purposes. In the first place gases in the make-up water are almost completely removed, and the condition of the water bettered by the heating it receives from the exhaust steam. Second, by being heated to 210° or 212° a considerable load is taken off the evaporator plant, allowing



LIVE STEAM DISTRIBUTION
FOR
WESTERN AVE. PUMPING STATION

smaller units than would otherwise be possible. Third, the preheater provides storage to take care of the fluctuations in demand, and also provides a place for filtering off any solids which may exist in the raw water.

The evaporator proper is known as a two-effect high pressure plant. It is so piped that it may be operated with either unit as a single-effect plant, but of course this would not be done in normal conditions. By the use of the double effect, a lower heat head is established in the evaporator unit which enables evaporation to take place without danger of priming and carrying unevaporated water into the system.

The operation of the evaporator will be as follows: The heated make-up water is pumped into the shells of both effects thru float-controlled regulating valves. The coils of the first effect are supplied with live steam, reduced somewhat in pressure and probably desuperheated for best results. The make-up water being further heated by the steam coils is vaporized and passes over into the coils of the second effect at a pressure and temperature considerably lower than the original steam supply.

Within the second effect the action is the same as in the first, with the exception that the vapor from the first serves as the heating medium of the second, and the final vapor formed is lower in pressure and temperature. In this case, the normal final vapor pressure is expected to range between 15 and 25 pounds gauge; and at this pressure is passed thru a small surface condenser, thru which the boiler feed water is pumped as circulating water. This provides an opportunity for raising the temperature of the boiler feed higher than could be done in open feed water heaters alone. At times it may be desirable to cut out the vapor condenser and lead the vapor directly to the feed water heaters.

The condensate from the steam coils and vapor condenser are trapped and returned to the feed water heater, so that actually the evaporator operates without heat loss from the system with the exception of slight radiation loss and blowdown loss amounting to not more than five percent of the make-up. The larger part of the scale forming upon the steam coils may be removed by cracking, accomplished by introducing cold water at intervals. The loose scale may then be removed from the base of the evaporator.

The main supply of boiler feed water is heated in either one of the duplicate open feed water heaters. Exhaust steam from the turbo-generator furnishes the principal supply of steam for the heating; but should the temperature within the heater drop a few degrees, steam bled from one of the main steam turbines is admitted thru a thermostatic valve, to make up the deficiency and maintain a feed water temperature at or near 212° at all times. All of the main turbines will be provided with bleeder outlets for this purpose, altho in actual operation probably only one will be floated on the heater line, because of the comparatively small quantity required.

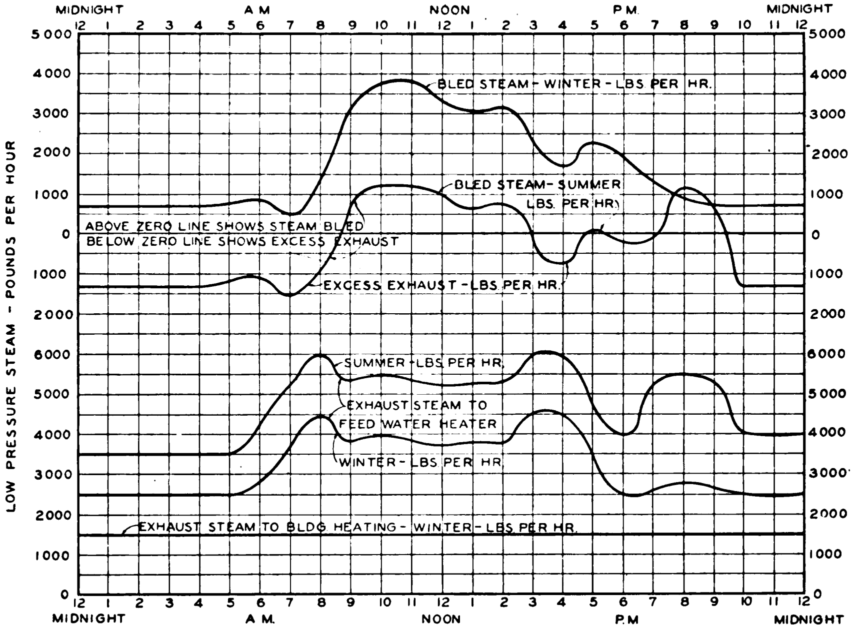
The heaters will be of the conventional tray type, and of ample size to heat the maximum quantity of water required. They will feed by gravity to the boiler feed pumps which rest on the floor beneath the heaters.

A few words about the feed pumps will be interesting in that they are small capacity centrifugals, pumping against an extremely high head. There are three pumps in all, one driven by a steam turbine and the other two by motors supplied from the station turbo-generators. To pump against the total head of eight hundred feet the motor-driven pumps will require eight stages arranged as two four-stage pumps in series with the motors placed between the two parts. Each unit will have a capacity of 200 gallons per minute, which is sufficient for the entire boiler requirement.

As mentioned before the discharge from the feed pumps passes thru the vapor condenser, where it picks up a few degrees of temperature before it finally enters the boilers.

A constant check will be kept on the amount of boiler feed water by means of recording and indicating venturi meters set in the discharge lines near the pumps. This type of meter has proved satisfactory and accurate for boiler feed supply.

One other point in connection with the feed water system should be mentioned here, and that is the provision for storage of distilled water. Two tanks for this



LOW PRESSURE STEAM DISTRIBUTION
FOR
WESTERN AVE. PUMPING STATION

purpose are placed in the basement of the auxiliary room with total capacity to fill an empty boiler without interfering with the feed process to the other boilers.

One of these tanks is floated on the main condensate line continually; and is kept filled from that source, rather than attempt to score the hot returns from the evaporators. The contents of this tank are automatically pumped to the feed water heater at times of low water.

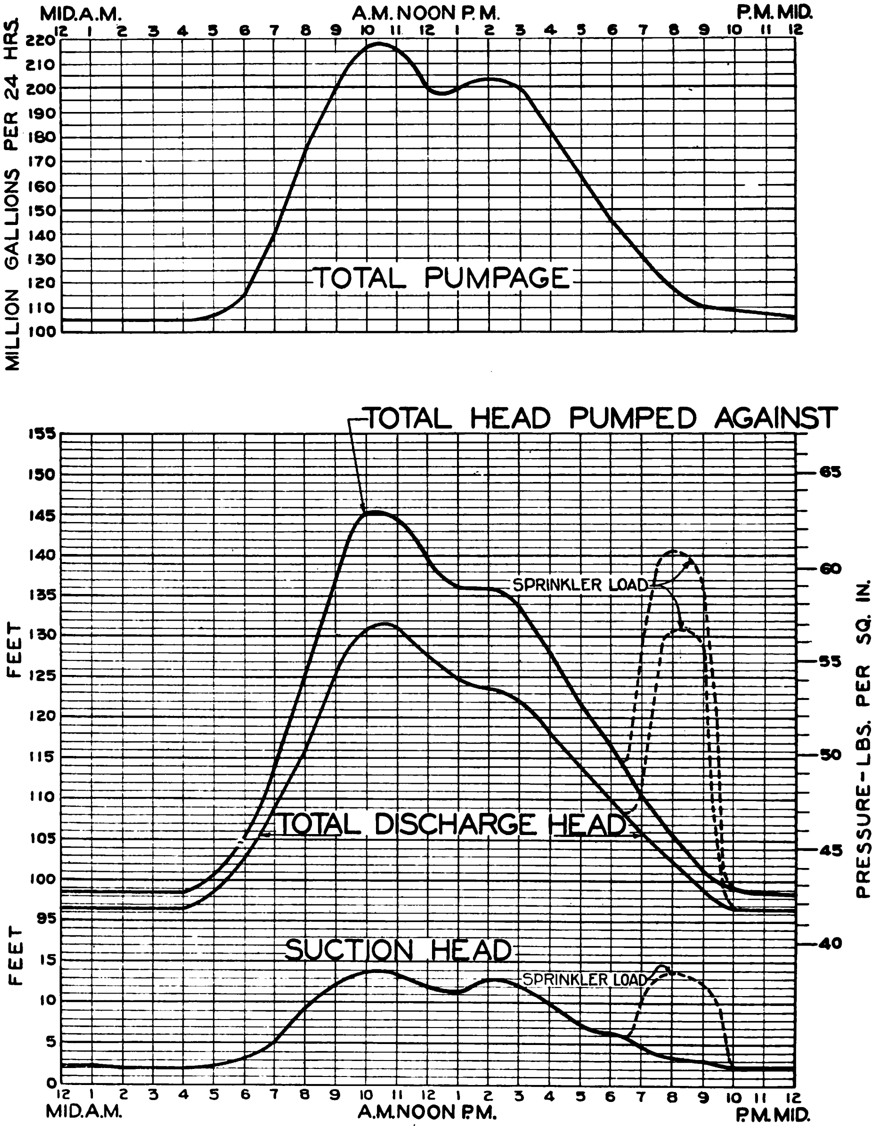
High Pressure Steam Piping

The first requisite of a pumping station being reliability, every effort has been made to design a steam piping system which will be extremely flexible and capable of delivering steam even though an accident should occur in any part of the line. In general the system is in accord with the most modern engineering practice as applied in large central generating stations.

The amount of steam required in the station is not large. At maximum load it should not exceed 75,000 pounds per hour with three of the main pumps in operation. The great economy of the main turbines due to the high pressure and superheat is of course, responsible for the comparatively small quantities of steam. An exhaustive study has been made on the use of high steam pressures and temperatures with a final decision to supply steam at 300 pounds gauge pressure and 200° superheat at the turbine throttles, giving a total temperature of 621° F. This does not mean that any of the steam equipment is in the experimental stage, but it does mean that the best modern practice has been adopted without sacrifice of reliability.

The arrangement of the station allows a rather simple layout of the steam piping with the single disadvantage that the leads must necessarily be long, due to the positions of the turbines in the deep pump pit. Double leads are taken from each boiler, one from each side of the superheater header and led to the duplicate steam header in the auxiliary room, where all valves are easy of access. Double leads to the steam-driven equipment are taken from the top of the header and joined into a single lead to

WESTERN AVE. PUMPING STATION
HEAD AND PUMPAGE CURVES



Notes:- Suction head includes 3 ft. friction loss.
℄ of pumps taken as Elev. -11.0'
Curb Elev. at 49th. Pl. & Western Ave. = +13.8'

the particular unit. Extreme flexibility is obtained, in that either header may be cut out entirely; or by use of the gate valves in the headers, a boiler and turbine may operate together as a unit system, very valuable for testing as well as for emergencies.

As mentioned before, the station layout requires long leads, and naturally a larger pressure drop, but by limiting velocities to 8000 feet per minute or less these pressure drops become of little consequence. The steam inlet piping for all equipment is brought up from beneath the floor; eliminating unsightly leads from above; and also lessening the chance of an accident to the piping, by a swinging crane hook or other cause.

The pipe, fittings, and valves used in this installation will be in accordance with the American Engineering Standards Committee recommendations for 400-pound steam pressure work. Cast steel bodies will be required on all valves and fittings as well as in the special manifolds to be placed in the steam headers. Joints will be of the lap type and fittings will be furnished with raised faces, requiring a thin gasket. All bolting and dimensions of flanges will correspond to the new standards.

Expansion in the pipe lines is great due to the high steam temperature. It has been taken care of by the use of long radius bends and by providing proper loops and anchorages. All pipe will be covered and drips provided at all low points and valves.

Heat Balance

The study of heat balance comes after the main units have been selected. Approximate quantities of steam can then be determined, and the required sizes of boilers and auxiliaries arrived at.

A study of the heat balance is necessary in order to prevent, as far as possible, the unnecessary loss of energy during the widely fluctuating pumping loads. This heat balance study naturally centers about the boiler feed water heaters.

In order to maintain a constant maximum temperature within the heater, means must be provided to supply extra heat at times of a deficiency of exhaust steam; and at times of a surplus of exhaust steam, a means of preventing its waste. At Western Ave. this is accomplished by automatically bleeding steam from the main turbines when steam is needed, and by diverting the evaporator vapor through the vapor condenser at times of surplus steam, so that more may be used within the heater.

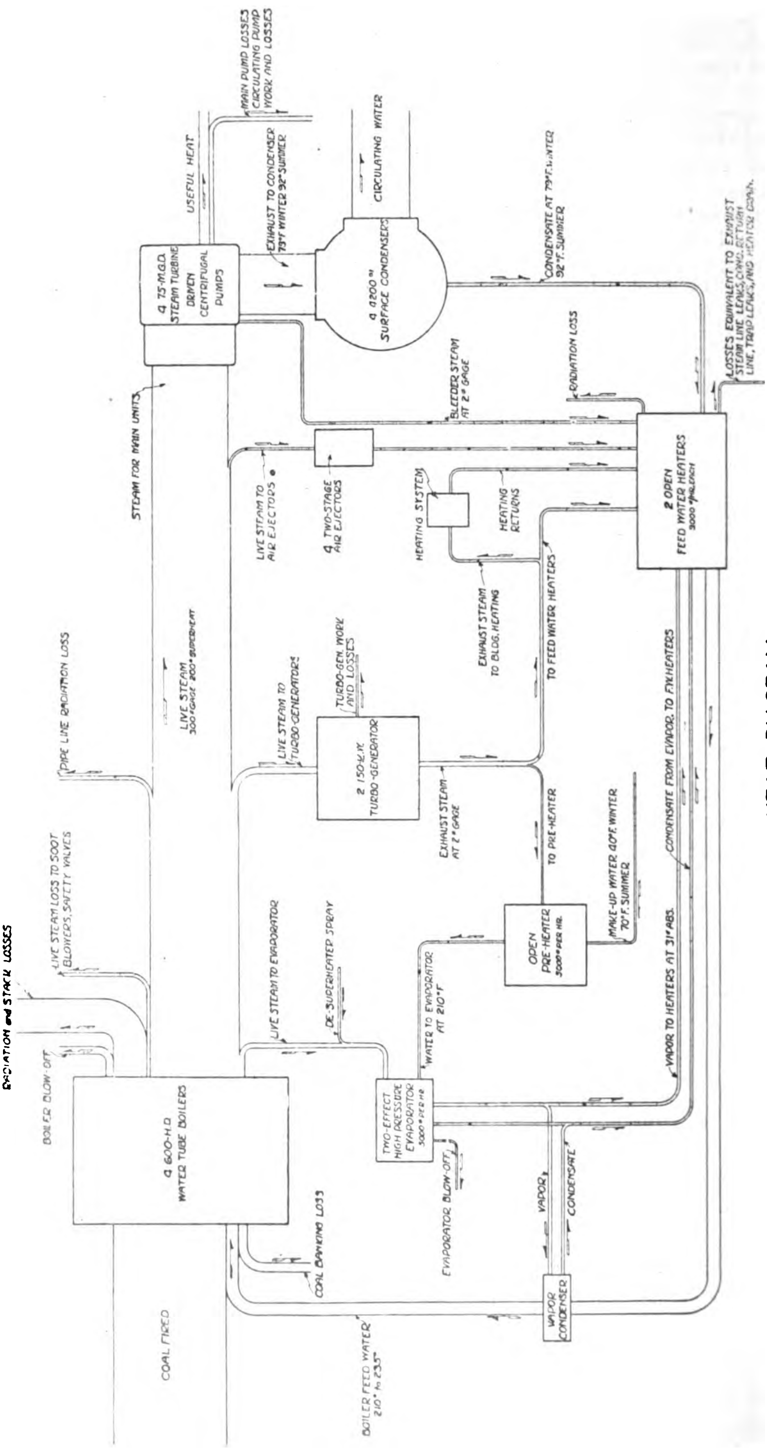
A brief outline of the path of heat from the coal fired into the boiler, to its final dissipation or use, is interesting, but does not depart from ordinary good practice.

Starting at the boiler, heat is supplied by the coal, and by that which is contained in the boiler feed water. A sizable proportion of this heat is lost immediately through boiler losses up the stack, to the ash pit, etc., leaving the remainder in the live steam leaving the boilers. This passes to the main turbines and auxiliary equipment with only slight losses due to radiation. The main turbines take about 85 per cent. of the total steam output, turning part into work and passing most of the remaining heat to the surface condenser, where the greatest heat loss occurs, it being carried away in the circulating water.

The pure condensate is, of course, pumped back to the feed water heater, where it is to be heated for boiler feeding again.

All steam used by the auxiliaries eventually finds it way back to the feed water heater, but has lost part of its heat while doing the work required of it. Losses of water and steam from the system are made up through the pre-heater, and are returned to the main heaters by way of the evaporation plant. The feed pumps are supplied from the heaters, and pump the heated water back to the boilers through the vapor condenser, and the cycle is completed. The vapor from the evaporators, exhaust from the turbo-generator, and at times steam bled from the main units has heated the condensate, and it is ready to be turned into steam again when more coal is supplied.

A distribution of heat has been made, which shows in a general way what happens to the heat in the coal which is fired into boilers. The figures are purely for design purposes, and a materially better showing is expected from the guarantees which have been made on the equipment to be installed. Instead of 10½ per cent. of the heat in the coal



HEAT DIAGRAM FOR WESTERN AVE PUMPING STATION

being turned into useful work, probably 11½ per cent. will more nearly approach the actual conditions. The boiler loss also will be materially smaller.

Engineering Design of Building

The engineering design of the building shows a substructure composed of heavy reinforced concrete retaining walls and a structural superstructure. The deep pump pit made necessary heavy concrete counter-fort retaining walls which are carried to rock. The stack foundation rests on caissons which are carried to rock. All the remaining substructure rests on hard clay. The entire soil underlying the station is hard dry clay. Bed rock is at about —39.

Architecture

The architecture features of the station have been developed by the City Architect, Mr. Charles Kallal. The design is along modern Gothic lines with the exterior of the front and sides of variegated limestone. The interior of the lobby and pump room will be of glazed terra-cotta with ornamental iron and brass railing for the visitors' gallery.

Summary

In closing I wish to call attention to the following facts in connection with the design of this station:

There is nothing unusual or experimental in any part of the structure or the equipment. Everything selected is of the very highest type as regards reliability and efficiency. The trend as regards steam pressure and temperatures has been followed, but still we have kept within a conservative range.

The design, construction and operation of everything connected with the water supply system is under the direction of Mr. John Ericson, the City Engineer, who, as probably most of you know, has given over forty years of his life to this work.

DISCUSSION

John Ericson, M. W. S. E.: Mr. Gayton has given an interesting description of what types of equipment we have decided on for this new Pumping Station and how we have proceeded to arrive at conclusions as regards these selections. This, however, does not tell the whole story.

The officials of a municipality under our laws, after decision has been made as regards the best types of equipment to be used, cannot thereupon proceed to buy what is considered best of the selected types of equipment, but must proceed either to make their own detail plans and invite proposals for the manufacture of the various machines on these plans, which in this case is rather out of the question, or to prepare specifications according to which bidders are invited to make proposals on their own respective designs.

To draw such specifications so as not to limit competition too much, and at the same time safeguard the City so as to prevent experimental and undesirable features in design is not so very easy. Each manufacturer has generally standardized his products. To specify certain features known to be desirable and important, but which are not to be found in perhaps more than one or two manufacturers' products, lays one open to charges of favoritism. To have the specifications too open, on the other hand, tempts some bidders to offer cheap and undesirable installations, and, when thus being able to underbid those who offer higher grade machinery, we at times have difficulty in preventing the acceptance of such inferior apparatus, especially if the bidder has political affiliations, which is not infrequently the case with such bidders.

It is true that in biddings where competitive designs are involved the Commissioner of Public Works, who in this City by law is the official who awards contracts for the Department of Public Works, is not necessarily required to award such contracts to the party bidding the lowest nominal price, but more often than not this official is part and parcel of a political machine, and political expediency rather than the City's best interest does not infrequently become the governing factor in the award of contracts.

Fortunately Chicago at the present time has a Commissioner of Public Works

who can be swayed by nothing but his sense of duty to the City of Chicago, and for this reason I am convinced that the equipment under contract for the new Western Avenue Pumping Station is in every instance all that the experience and the best judgment of the City's engineers charged with the design and recommendations for these installations could desire. Had that always been the case our municipal plants would be in better shape than they are today.

As regards the selection of types of machinery for our large stations, I wish to say that, while we want to be progressive, and I believe we are, a certain conservatism must be maintained when it comes to these vital plants.

Electric power for operating such stations has been, and is gradually being, adopted in many places. I believe that this type of installations will come more and more into use. Personally, I find much in favor of electrically operated stations. Chicago, as you know, now has three large pumping stations thus equipped and operated. Our experiences with these stations, however, have shown that so far there is no positive assurance of uninterrupted service at all times. There have been occasions when all three stations have been put out of service simultaneously for a shorter or longer period. With two large electric stations already located on the South Side of the City it was not deemed advisable at this stage to install a third of still larger capacity in this territory, even had the cost been shown to be less than for a steam operated station.

Diesel engines are another means of motive power for this purpose to be reckoned with. It would not surprise me to see the Diesel or other similar machinery, as well as electric motors, gradually relegate steam turbines, as well as reciprocating pumping engines, to the scrap heap, as far as this kind of service is concerned, but we did not believe that that time was yet at hand when deciding on types for this new large-capacity station, and especially under the conditions that have for a long time existed and still exist as regard the Chicago Water Supply System.

TECHNICAL PAPERS

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A New Type of Gas Storage Holder

By Alten S. Miller*

Presented January 19, 1925

Piston type gas holders have been used in Europe for several years but only two have been built in this country. The principal saving in cost is in the foundations which are required to carry a much lighter load due to the lightness of the structure. The vital point in this type of holder is the seal between the piston and sides of the holder which is accomplished by means of a tar seal.—Editor.

THE waterless gas holder differs from the older type in that a piston moves up and down inside of a fixed envelope, instead of the entire holder moving over and in a tank of water.

The structure in which the piston moves is a polygon having from 10 to 28 sides, depending on the size, and having a height varying from one and a fifth to one and two-thirds times the diameter of a circle circumscribed around the polygon. The structure is roofed over, but usually has windows in the sides immediately under the eaves so as to permit the illumination of the piston and the side walls above the piston.

Figure 1 shows a section of the holder. The only moving part is the piston shown as a truss in the middle of the holder. The piston itself is trussed and plated so as to hold gas and to give it the necessary rigidity to permit it to be guided by rollers and to maintain it in a horizontal position. The method of guiding is similar to that used in water tank holders, except that no tangential rollers are used. In the place of the tangential rollers at each column, two pairs or more of brass rubbing strips are used in the entire holder. The vertical distance between the rollers is about one-tenth of the diameter of the holder.

The joint between the piston and the holder walls is made by a tar seal which is the vital problem in the holder and which is shown in Fig. 2.

Figure 2 shows some of the detail of the tar seal. The vertical line on the left with the projecting parallel lines indicates the side of the holder; the rest of the structure is a part of the piston. The tar seal consists of a rubbing plate turned up slightly on the edges to cause it to glide smoothly as the piston moves. The plate is kept in contact with the side of the holder by weighted levers and the plate is thin enough to accommodate itself to any slight irregularities in the surface against which it moves. The joint between the plate and the piston is made by canvas attached to the back of the plate and carried over to the side of the piston as shown. The canvas runs over a wood rod to keep it from touching the side of the holder and lies on a wood strip. It is not subjected to friction or to other strain than that caused by the weight of the tar and should last as long as the foundation under the holder.

This same picture shows the form of the sheet used for the plating. The bottom of each sheet has one bend and the top two, the bends being designed to provide the necessary stiffness and to facilitate the riveting.

Such tar as may leak past the rubbing strip will run down into a reservoir made by placing a dam sheet four or five feet

* Vice President Bartlett-Hayward Co., Baltimore, Md.

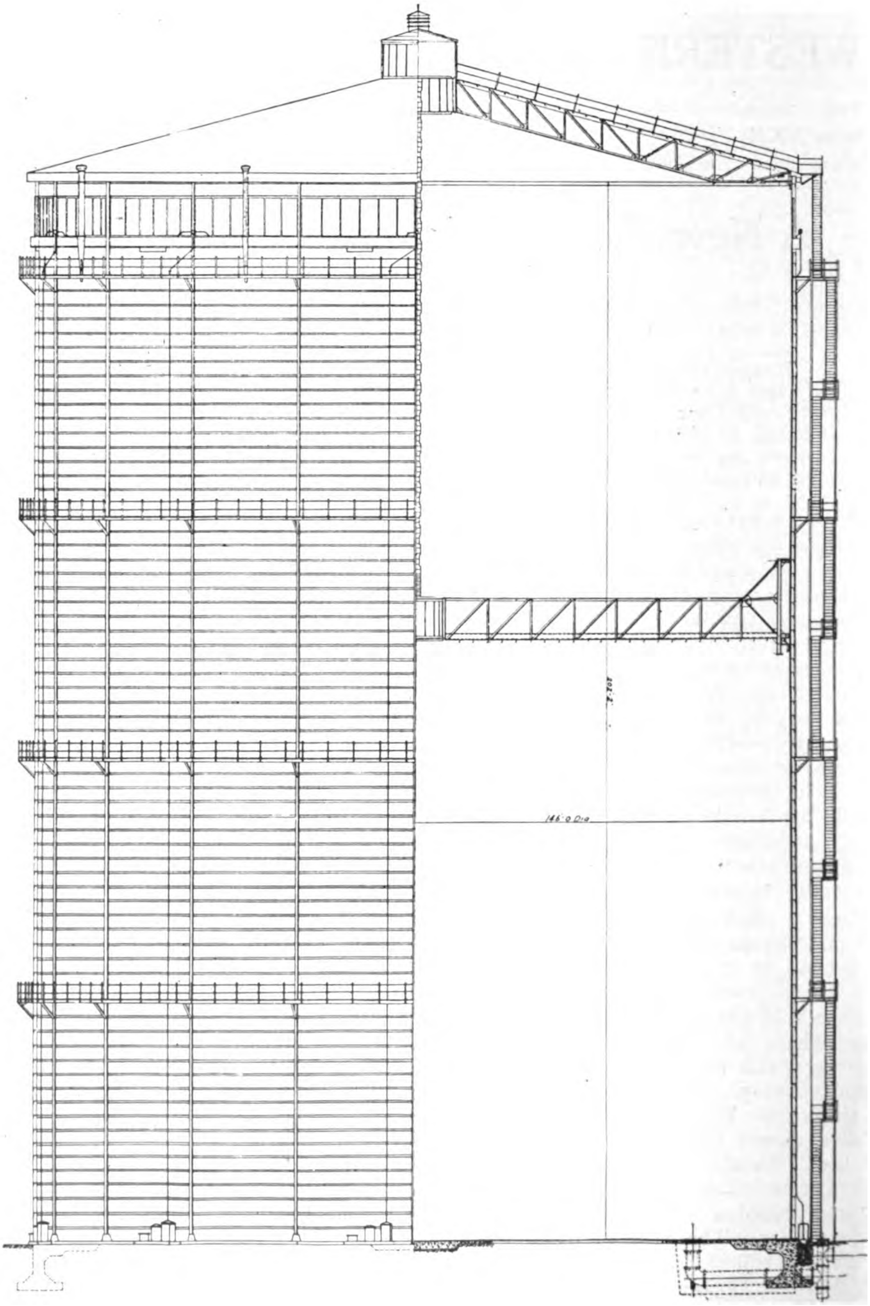

FIG. 1. CROSS SECTION OF THE PISTON TYPE WATERLESS GAS HOLDER.

inside of the holder sides at the bottom. From this reservoir the tar flows under a diaphragm and over an adjustable weir to a tank. The tar being heavier than water will flow under the diaphragm and the water will remain in the reservoir. There are usually about half as many overflows as there are sides to the holder, and in addition there is a water overflow similar to those provided for the tar except that the diaphragm is omitted. The weir in the water overflow is kept slightly higher than in the tar overflow.

bend on the outer edge having a depth of 2½ in. The columns are bolted at the bottom to the foundation and, with the plates, form stiff girders to withstand the wind pressure.

The windows may be seen at the top of Figure 3 and also there may be seen three galleries which run entirely around the holder. These galleries are not designed to strengthen the holder, but are for the purpose of inspecting and pointing. The pipes carrying the tar from the overflow tanks at the bottom to the storage tanks at the top may be seen in the picture. The upper tar tanks are immediately below the windows.

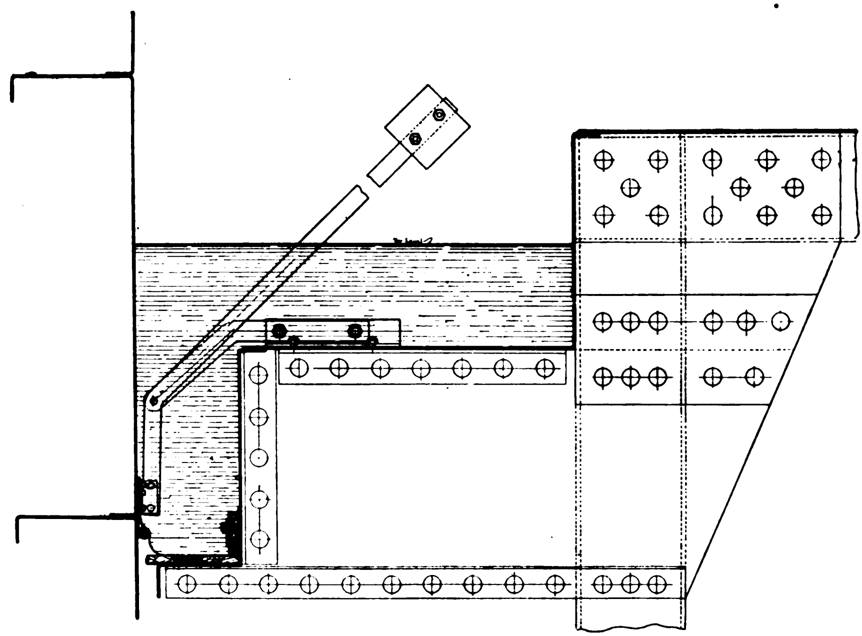

FIG. 2. DETAIL OF TAR SEAL BETWEEN PISTON AND SIDES OF HOLDER.

When the tar rises above a predetermined level in the overflow tank, a float rises and throws the switch which starts the pump. The tar is forced to tanks between the level of the upper gallery and the line of windows.

Figure 3 shows the first holder that has been completed in this country, located at Michigan City, Indiana. It has a capacity of 1,000,000 cu. ft. and is 105 ft. in diameter, and 136 ft. 8 in. from the top of the foundation to the eaves.

The sheets are made of No. 9 steel and the columns are made up of eye beams. In order to stiffen the plates between the columns they are bent or flanged over to a depth of 7 in., with a second

When a certain amount of tar drains from the holder into a tar tank on the ground a float is raised which automatically starts the motor operating the tar pump. Tar is then pumped into the two tanks served by that pump and which run the length of the two sides adjacent to the pump between the upper gallery and the windows. Under ordinary operating conditions the tar flows immediately from the tar tank, which is kept full, to the piston seal. If for any reason additional tar is required, a valve under the bottom of the storage tanks at the top

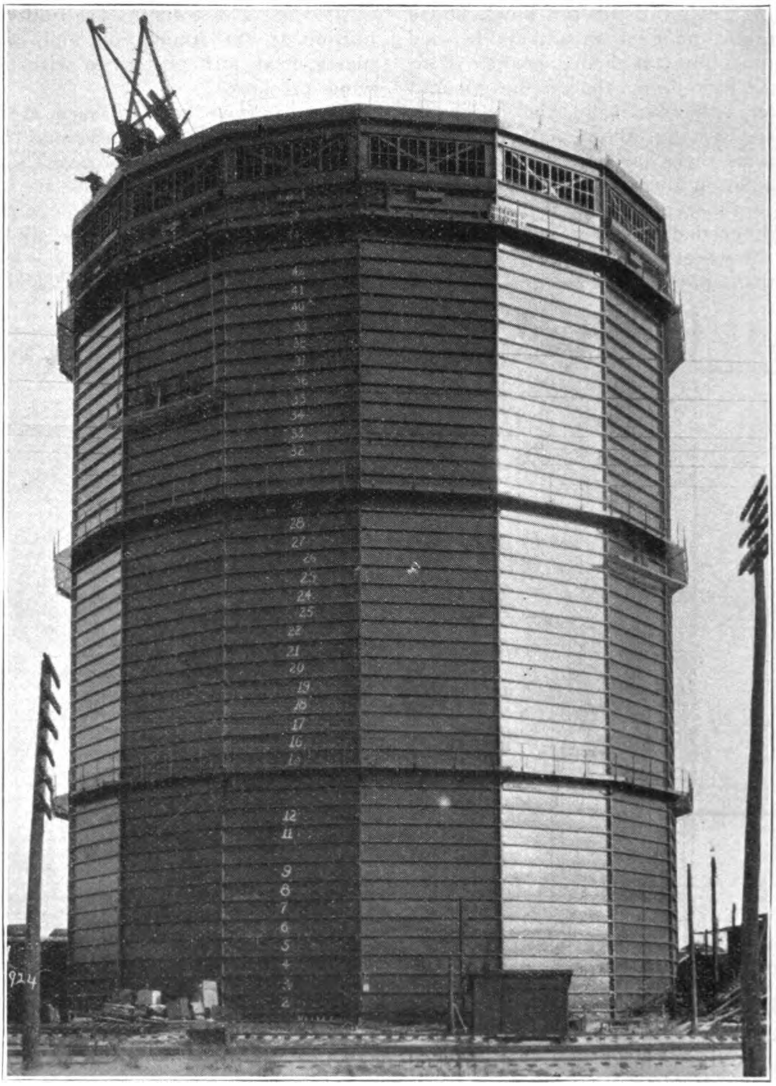

FIG. 3. WATERLESS GAS HOLDER JUST COMPLETED AT MICHIGAN CITY, IND.

of the holder may be opened and the tar permitted to drain through the distributors to the piston seal.

The pump used for raising the tar was especially designed for handling heavy and viscous liquids and after ten years of operation has been found to be particularly well adapted for service in connection with this type of holder.

At intervals around the perimeter of the holder, slightly below the top, are slots connected with pipes running above the level of the roof. As the piston rises a small amount of tar from the seal will run into these lots after which the rubbing bar will pass over them. After the rubbing bar passes these slots such tar as may have run into them will flow back under the rubbing bar into the holder and gas will blow through the

vent pipe or pipes. This will prevent the piston being raised high enough to damage the roof.

A ladder is provided in the center of the holder which folds on the piston as the latter rises, and unfolds as the piston falls.

The method of erection is somewhat unusual in that the roof is built on supports resting on the piston while the latter is on the ground, and afterwards the holder is built and the roof connected in its final position. The machinery for lifting the structural material is placed on the roof in a manner generally similar to the method of construction used in the older type of holders. As each line of sheets is put in place the piston is blown up with air to a new position and is hung by hooks to plates which are fastened to the columns. In the new position an additional row of plates is put in, but all work is done while the piston is hung on the special plates and not while it is floating on air.

The scaffolding, from which the men work in assembling and riveting outside of the holder, is hung from the piston or roof and therefore everything moves up together. During the construction period no tar is used in the seal.

A special hook and scaffold is used in the erection of this holder. Two plates are attached to the column, the distance between the supporting points for the hook being equal to the width of the holder sheets. As the piston is lifted following the completion of a row of sheets, the plates are raised to the next position so that no time is lost in the operation of raising the piston and locating it at the successive working levels.

When the scaffold is at its highest position and therefore when the gallery is complete the platform is disassembled and lowered to the ground. The lower galleries are built from the lower scaffold platform before it is raised to the upper level. This platform is hinged on the outside and after each gallery is built it is dropped to a vertical position and drawn up past the completed gallery.

In July, 1923 at Buer, Germany, a holder having a capacity of something over 900,000 cu. ft. used 91 kw.-hr. in 26 days for pumping the tar which seeped pass the rubbing bar. During December this same holder used 6.7 kw.-hr. and during April, 1924 it used 25 kw.-hr. showing that the cost of pumping is nominal.

The advantage of this type of holder is a material saving in the cost of foundation, where the ground has but a limited bearing power, less capital required for boiler plant, a saving in steam for heating and materially less expense for painting. In the case of a 6,000,000-cu. ft. capacity water tank holder, the load on the foundation is 90,000,000 lb., whereas in the case of a waterless holder of the same capacity the load will be approximately 6,000,000 lb. The difference is not a serious one, if the ground is firm and if it has a bearing power of a ton and a half or more per sq. ft., but, the advantage in the case of a waterless holder is very great, if the bearing power of the ground is 2,000 lb. or less per sq. ft.

The bending of the sheets of the length and thickness used in this construction requires the services of a brake of unusual size and stiffness. No such machine was available and therefore it became necessary to build the brake before work could commence. Instead of having a bearing at each end, as is ordinarily the case, this machine has a bearing about every five feet; its total length is 32 ft. This machine is so rigid in every part that with it plates may be bent to almost exact angles and dimensions.

Ten years of steady use has proven this design to be practical and satisfactory in all respects. During this period forty or more holders have been completed and a number of additional ones are under construction and under contract.

Lubrication in Steel and Cement Mills

By J. A. Marland*

Presented January 5, 1925

Steel and cement mills present conditions which make the problem of lubrication of machinery difficult. The evolution of lubricating systems resulting in the carefully studied practices of today is traced through its several steps in this paper. Use of a single lubricant for all purposes has resulted in important changes in design of machinery. Some cement-mill equipment cannot be so lubricated.—Editor

RIVALRY and cut-throat competition in turning out steel as recorded in the history of early Carnegie and Bessemer days, was chiefly concerned with the development of machinery, which would insure the lowest production cost and greatest volume of output in the shortest possible time. New designs of mills brought changes in power transmission, in proportioning of those roll-mill members that showed weak points, as also in the arrangement of handling the material through its various stages to final completion.

Hand Oiling of Bearings

When steel mills were scrapped after only one year or six months production, due to development of more rapid production mills, perhaps it was just as economical to arrange for hand application of grease or oil to the mill bearings. This is, of course, with regard only to the length of life of the mill and without regard for oiling labor economies which could, perhaps, have been offset by an automatic oiling system to replace frequent manual attention.

As the weak points of steel mills were eliminated, and as the mill owners came to realize that fairly satisfactory progress had been made toward production speed they also came to realize that further improvement could be made in prolonging the life of the mill, as also in eliminating oiling or greasing labor charges and waste of lubricant by providing a continuous automatic lubricating system. Thus the development in the lubrication of steel mills, was toward continuous, automatic, positive oil delivery systems, with ample provision for draining and returning of oil to a central point. Such returned oil is automatically cleansed of impurities with which it may have become polluted while flowing through hundreds of mill bearings. After the oil is thus purified to restore as nearly as possible its original characteristics, depending on its quality or chemical structure and purity, it is again ready for use.

Gear and Pinion Lubrication

In the problem of gear and pinion lubrication we find a more severe condition as regards the film-rupturing tendency, than is encountered on bearings, for the reason that shocks to bearings are transmitted through oil films spread over the bearing area, whereas shocks between gear or pinion teeth are transmitted practically through what might be called line contact. The best illustration of this point can be shown by comparison of bearing area pressures, which range as high as a few hundred pounds per square inch, whereas gear and pinion tooth pressures may range to several thousand pounds per lineal inch, assuming one engaging tooth. This latter computation is based on maximum power demand by one set of rolls which the pinions under consideration are driving, and assuming only one line of tooth contact.

Past practice in lubrication of gear teeth has invariably included the use of extremely viscous gear "dopes" or compounds. These were sometimes so thick as to require heating before application could be made with a paddle, or by simply pouring from a bucket. In many cases no provision was made for drainage or reuse of such a heavy gear dope. In other words, the entire volume of lubricant, by such application, ran to waste, with the exception of a small percentage which may have adhered to the teeth and gear sides or hubs.

Naturally, there was no great need for

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* Vacuum Oil Co., Chicago.

a highly refined or carefully selected lubricant under such conditions of use, and steel mill lubricant buyers came to the conclusion that the cheapest and probably the most viscous dopes would prove most economical and most satisfactory. Despite this apparent economy the lubricant cost per ton of production was much higher than by the present method, which is simply the continuous use of a carefully refined, high grade and properly selected lubricant, as has been employed in high speed turbo-generators for many years.

Continuous Gravity System

The use of this continuous automatic lubrication system has been gradually developed, within the last ten years. The first circulation systems included delivery and drainage of bearing oil only. This applied to bearings of the drive shafting. Naturally the engine bearing system had been in use for a much longer time, hence, this extension was nothing more than a slightly improved design of drive shaft bearings, so as to prevent excessive loss of oil and to permit its return through suitable piping. Later this system was extended to supply oil to pinion stand bearings.

The use of heavy gear dopes on pinion and gear teeth of continuous mills made it practically impossible to keep some of this extremely heavy, almost tar-like material from creeping into the bearing oil system, eventually clogging the flow of oil either in the drain lines or filters. This also endangered destruction of bearings through obstruction of oil flow at needle valves in the feed lines to bearings.

Simplified Central Circulation System Employing One Lubricant Only

Within the last few years experiments conducted in test shops and under actual working conditions, with the cooperation of engineers who have specialized in lubrication, have developed the fact that teeth of reduction gears, pinions and of driving gears, could be lubricated with an oil which would still be light enough to satisfy the bearing needs. This development came from careful study of viscosity-temperature conditions, occuring on heavy-duty reduction gear sets and pinion stands, where it was found that overheating of extremely viscous lubricants occurred until the resultant viscosity was but little higher than of such an oil as was just mentioned. This increase in temperatures of the extremely viscous gear dopes would naturally be caused both by the fluid or plastic friction of the dope itself, and also by the metallic friction developed between the gear teeth resulting from bare spots, where the heavy dope did not flow quickly enough to prevent metallic contact.

Bath Lubrication of Gears

The first attempt to employ the same oil for bearing, gear and pinion lubrication was simply a copy of the then existing practice, i. e., merely replacing the extremely heavy dope with oil. In other words, the oil was placed into the gear case and pinion stands, so as to bring the teeth below the level of the oil, depending on surface adhesion of the lubricant to carry it to the line of tooth mesh.

Although this plan proved satisfactory in some cases, probably where lineal pressures were not so great, it was found that dangerous overheating likewise occurred, thus proving that fluid or plastic friction alone was not the cause of overheating in such gear cases. Dissipation of heat from the gear case oil-bath was necessary. Pitch line speeds and centrifugal action also entered as serious factors.

Pressure Spray to Teeth

Applying the lesson which Lubrication Engineers had learned in the case of cutting-tool lubrication and cooling, we next developed the plan of positive pressure spray to gear and pinion teeth. This was done in such a manner as to insure a copious stream of oil along the entire line of mesh. Pressures of ten to thirty pounds in the oil line, at the point where connection is made to the spray nozzles have been found ample. This is, of course, within safe and satisfactory piping practice, being approximately in the range of oil pressures on turbo-generators, especially turbo-gear units.

One of the problems which next confronted these plants of "one oil lubrication" was the purification of the oil for removal of atmospheric impurities which would enter gear and bearing cases, even despite very close attention on the part of mill designers and builders to provide

for dust tight construction. It is, of course, impossible to make such a system air tight which would include piping to hundreds of bearings, spread over a total run of several hundred feet, with many drainage connections. Water splash from the cooling supply to the rolls also was and is a factor, the water entering the oil system from the drain shelves of pinion stands. Other pollution which had to be considered and removed from the oil, was metallic particles which resulted from slight tooth abrasion where gear teeth had not been perfectly aligned, and also iron rust and scale from the large gear housings and piping, core sand from cast bearing pedestals, etc.

Manufacturers of oil equipment did their part in this economical progress by developing simple filtering equipment which helped to remove impurities, either by gravity precipitation or by passage through closely woven cloth. The use of centrifuges for removal of some finely metallic impurities has also been of value, better perhaps as an auxiliary, or superfine method, in addition to the settling tanks and filters.

Since the use of one oil for both summer and winter service would be most desirable in the system of several thousand gallons capacity, another problem of correct performance during both winter and summer periods entered the situation. This problem was met in a very satisfactory manner by paralleling both oil feed and drainage lines with low pressure heating lines, and in some cases wrapping these together in a common insulating binder. To avoid "cracking" or decomposition of the lubricant, no direct contact of liquid oil and steam coils is permitted.

Further viscosity control for summer periods was provided by installing ample cooling coils in overhead gravity tanks. This provision controls the temperature of the oil very satisfactorily between extremes of 60° to 110° F. of the oil in feed lines. We have thus been able to employ a free-flowing lubricating oil which can be supplied with a gravity pressure of 25 to 40 pounds to regulating valves for all bearings of such a system, including enclosed carrier roll bearings, drive shaft bearings and gears, pinion bearings and teeth, also auxiliaries whose location may be limited only by the capacity of return drainage lines, although even this can be taken care of by providing several drainage sumps, and repumping to the main settling and filtering tanks.

The positive application of fluid or semi-fluid lubricants to roll neck bearings, either through high pressure application with lubricant compressor or grease guns, or through individual reservoirs which will permit recirculation will probably replace the present method of hand application or tamping of grease into bearing pockets.

Roller Bearings

One of the most advanced steps along this line has been the development of dust-and-water-tight roller bearings, which are designed at the present time to take care of mills up to sixteen-inch size. The development of such bearings and the provision of means for their quick removal when changing rolls, thus insuring all the advantages of quick change which heretofore have been claimed for plain bearings, and without involving the disadvantages of bearing wear as occurs with plain type bearings under such extreme pressures, promises soon to be the standard practice in up-to-the-minute mills. The lubrication of such bearings will, naturally, be a simple and easy problem since it will involve nothing more than slip connections for oil circulation, or even a simpler plan of packing individual bearings with cylinder oil. Periodic renewal of such a lubricant, say once in several months, or once per year, depending on the effectiveness of the seal to exclude foreign matter, as also on the quality and stability of the lubricant, will replace the practice of frequent addition of extremely thick roll greases or oils as now employed.

CEMENT MILL LUBRICATION

Some of the most important cost items in cement mill production, wherein the efficiency of lubrication may be reflected, are the following:

a. Power.
b. Repair of parts due to frictional wear.
c. Depreciation of machinery.
d. Production interruption or decrease due to forced shut-down.

e. Cost of lubricants per unit of production.

Lubrication will reflect most favorably upon these items by adoption of the two basic principles, namely:

1. Correct selection of lubricants best adapted for use on the respective equipment, and under prevailing conditions of operation.
2. These lubricants must be properly applied to the equipment.

The last stated requisite is further qualified in actual practice by the necessity of conforming to existing design of bearings, gears and existing lubricating methods.

Further in this connection it must also be realized that the most important problem in the lubrication of cement-mill machinery, as we find it today, is that of excluding atmospheric abrasive materials from reaching the journal surface or lubricant film. In this case as also in in the case of large machines in other industries, it is very difficult to design and build mill equipment with bearing and gear housing, where complete safety from dust intrusion would be assured.

Many ideas have been advanced to guard against such dust intrusion, some of these ideas succeeding to a surprising extent. These plans range from complete enclosure of gears and bearings with oil tight packing or gaskets surrounding the shaft, to partial enclosure of bearings only.

Although the partial-closure design has the drawback of allowing abrasive dust to associate with the lubricant to some degree, such design has nevertheless been a marked improvement over the policy which simply accepted the evil of dust contamination as unavoidable.

Quarry Equipment

The most important equipment, so far as lubrication is concerned in cement-mill quarries, includes air, steam or electrically operated drills, steam shovels and shifting engines or locomotives.

Steam or Air Drills

So far as application of the two basic principles above mentioned, can be made to steam or air drills, we have found that the most important step is to select properly compounded oils, and then to apply these as automatically as the design of drills will permit. So called "heart beat" oilers are, perhaps, most satisfactory for uniform delivery of oil to internal surface of such drills. In many cases the practice is simply to put in a small quantity of oil into the air or steam line or valve connection before the drill, at regular periods, thus providing some degree of uniform lubrication depending on the frequency of application.

Electric Drills

As a rule, lubrication of electric drills is a very simple problem resolving itself to motor bearings and simple shafting or drum bearings, most of which are normal to slow speed with moderate pressures. Perhaps, the most specific requirement is that of a high grade electric motor oil or grease, which will remain in proper fluid form, even during extreme temperature changes. Although the plan to provide a special winter lubricant can be very easily arranged, it has sometimes been overlooked at different quarries resulting in destruction of motor bearings, due to use of an oil unsuitable to low temperature service.

Drill and Shovel Cables:

Approximately the same condition of lubrication exists on electrically driven shovels, as already mentioned with regard to drills, excepting the additional wire rope or steel cable lubrication requirement which may require closer attention, due to the more severe shock service. This same condition applies to steam shovels.

The necessity for preserving and lubricating steel cables is of vital importance, although not generally appreciated. Especially is this true in the case of quarries where cables are exposed to the weather, with moisture penetrating the strands, thus endangering rusting of wires, and rotting of the hemp core. It is, of course, understood that whenever a cable or wire rope passes over a drum or sheave it not only rubs over the outer surface, but the individual strands rub on each other, and unless proper lubrication is provided on these rubbing surfaces, unnecessary wear occurs. Hence, in analyzing the lubricating requirements of cable

or wire rope, we consider the case as we would a piece of machinery, having many wearing surfaces that must be thoroughly lubricated. This analysis leads us to the selection of the lubricant which should consist of a heavy viscous oil, that will penetrate between the wires and strands, as also to form an elastic coating on the exterior. It should not harden on the outside, as this would allow the lubricant to crack in bending over the sheaves, thus permitting moisture to penetrate to the center and cause internal corrosion.

Tar should never be used as it forms a hard shield on the outside of the rope and does not penetrate to the inner parts.

Before application of the lubricant the cable or rope should be perfectly clean and dry. The lubricant should be applied hot whenever possible, thus rendering it sufficiently fluid for penetration and thorough distribution through the internal section of the rope. Subsequent cooling will thicken the oil to its original consistency, under which conditions it will have the necessary adhesive properties to maintain a continuous film on all of the wire surfaces. We have found that approximately one gallon of such lubricant should properly saturate and lubricate twenty feet of rope. Expressed in another way each foot of cable will require about one and one-half gallons per year. Where a rope or cable is kept in continuous daily use it may require at least one thorough application of such lubricant per week. In some cases this application may be required daily depending upon the speed of service.

Steam Shovels:

The wear and tear of steam shovels is very much greater than on almost any other kind of equipment, due to the fact that they are continuously exposed to all kinds of weather, and being employed for work which subjects the mechanism to a very severe operating strain. Both of these adverse conditions shorten the useful service of the shovel, that is its earning capacity.

Internal lubrication of steam valves and cylinders can be best arranged by selection and use of a properly compounded oil to insure adhesion on hot, wet surfaces. Automatic application of such an oil from mechanical lubricators through atomizers, as is customary for larger stationary steam engines, completes the care of internal lubrication.

Where automatic lubricating devices, such as sight feed oilers or wick feed cups, are provided on bearings of steam shovels, the use of a good quality oil, selected with proper regard to ability to stay on the rubbing surfaces for a maximum period, will be most beneficial. Where bearings are fitted with grease cups or high pressure grease compressor fittings, the use of a non-drying, non-caking, medium consistency grease will be found most satisfactory.

Crushers:

Crushers are large, heavy, hard-working machines used for breaking the quarry product, and because of the extreme importance that all heavy-duty frictional surfaces be amply provided with a suitable lubricant, this is one of the cases where the principle of automatic continuous circulation best serves to prevent metallic abrasion, and decreased life of the unit.

Provision for continuous circulation of properly refined high grade oils to such bearings and gears as found on gyratory crushers, is a standard design with some of the leading crusher manufacturers. To a lesser degree, automatic application especially on jaw and roll crushers is provided through use of ring-oiled or chain-oiled main bearings. Pitman bearings on jaw crushers can be very satisfactorily lubricated by means of wick or drop oilers, feeding through dust-tight connections to waste-packed reservoirs from which the oil passes to the bearings.

Compeb and Kominuter Bearings:

Although grease lubrication of such bearings has been excepted as fairly satisfactory in many cement mills, we have recently had the opportunity of developing even more satisfactory lubrication through the use of properly refined lubricating oils, automatically applied. No change in bearing design or construction was involved, with the exception of a simple provision to exclude dust at the bearing caps and at bearing ends.

Due to the comparatively large size of such bearings this provision of guard-

ing against dust intrusion, with a simple padding of felt and oil saturated wool waste, permitted economies of power saving, and frictional temperature reduction, to be realized.

This advantage was chiefly obtained through substitution of a fresh automatic supply of oil along the entire bearing surface, in replacement of a heavy packing of grease, which soon became charred or glazed where it laid in contact with the journal. In fact it is not an uncommon matter to find deeply scored journals and badly worn bearings on such mills.

Since each form of bearing design on already existing compeb and tube mills must be treated as a separate case, it is impossible to specify any general type of device for use on such bearings, except that the oiling device itself, that is the wick or gravity feed oiler may be of a very simple standard type, so long as it allows for desired adjustment of oil feed.

A few pints of correctly selected oil per week on a large bearing of compeb or tube mills, is usually ample if properly applied so that the economy of this means of lubrication, with regard to the lubricant cost itself, is also a favorable factor, although not by any means of prime importance.

Labor Saving:

One of the important advantages assured by this plan of automatic lubrication, aside from the advantages of power saving and greater safety by maintenance of a continuous fresh lubricating film in the bearing, is that of freedom from the need for frequent labor attention. This is achieved by the use of oiling devices of suitable size, so as to provide ample feed for periods of at least several days between attention.

Automatic lubrication of conveyor bearings is limited to ball or roller type bearings, where these are incased in lubricant-tight housings. Other types of conveyor bearings, usually provided with grease compressor fittings or grease cups, naturally, will continue to require manual attention from time to time.

The Waterproofing of Railroad Bridges

By G. A. HAGGANDER,* M. W. S. E.

Presented January 12, 1925

Experience has shown the importance of careful attention to the waterproofing of railroad and other overhead structures so as to prevent expensive repairs due to leakage. In this paper Mr. Haggander describes the failures of earlier methods of waterproofing and gives a complete specification for work that has been found to be the most satisfactory to date. Further progress will undoubtedly be made along this line. Provisions for waterproofing should be incorporated in the design of the structure.—Editor.

WATERPROOFING of railroad bridges has become an increasingly important matter in recent years due to the necessity for eliminating grade crossings by track elevation. A paper on this subject was presented before this Society on March 18, 1912, by W. H. Finley, (Past Pres., W. S. E.) now President of the C. & N. W. Ry. Co. The paper and its discussion outlined very thoroughly the practice of that date. That waterproofing was not developed to a final state was shown by the difference of opinion expressed on many important points and by the changes and developments made since that time.

Mr. Finley advocated for the waterproofing of ordinary concrete surfaces, a primer coat of asphalt, then a coat of liquid asphalt covered with a coat of mastic composed of one part asphalt and four parts sand. On top of this he placed a swabbing of hot asphalt and covered the surface with washed gravel. A membrane of burlap was to be used only over joints and at ends of bridges to give added strength. Others advocated a membrane of burlap and asphalt, felt and asphalt, or felt and pitch reinforced with cotton drilling.

At the present time the membrane system, using cotton drilling or felt, is almost universally used in conjunction with asphalt or pitch in the following combinations, the cotton drilling and asphalt combination being the most widely advocated.

Type 1 waterproofing consists of three moppings of asphalt and two layers of asphalt-treated cotton fabric.

Type 2 consists of three moppings of coal tar pitch and two layers of pitch-treated cotton fabric.

Type 3 waterproofing consists of six moppings of asphalt, four layers of asphalt-treated felt, and one layer of asphalt treated cotton fabric. The cotton fabric is the middle layer.

Type 4 consists of six moppings of coal tar pitch and four layers of pitch-treated felt with one layer of cotton fabric. The cotton fabric is to be the middle layer.

For points requiring additional layers of cotton fabric or metal reinforcement are to be applied. The membrane is protected by a covering of asphalt and sand mastic, concrete or brick.

The reasons for waterproofing are:

1. To prevent water from reaching a protected area.

2. To protect metal and concrete work from deterioration especially by brine or electrolysis.

The factors affecting the success of waterproofing, shown in the order of their importance, are:

1. The proper design of the structure.
2. The proper application of the waterproofing materials.
3. The qualities of the waterproofing materials.

Some of the factors affecting the proper design of the structure, including some reference to the membrane and protecting covering, taken from the American Railway Engineering Association manual, are as follows:

1. The structure should be designed so that it can be waterproofed and it should be adaptable to waterproofing by ordinary methods.

Good workmanship being vital to the success of waterproofing the design should be such that extraordinary pre-

* Bridge Engineer, C. B. & Q. R. R. Co., Chicago.

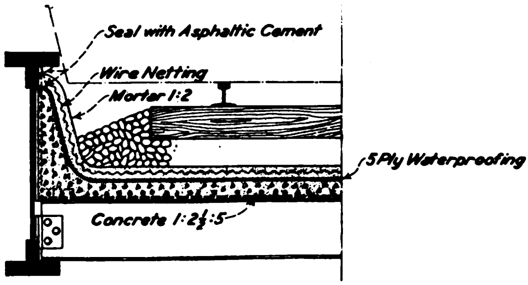

FIG. 1. WATERPROOFING PLATE GIRDER BRIDGE WITH CONCRETE DECK AND PROTECTION COURSE.

cautions or methods will not be necessary to secure good results.

2. Strength and stiffness are desirable features in a structure which is to be waterproofed.

The lack of these may permit destructive stresses in the waterproofing. Very shallow floors should be avoided whereever possible.

3. The structure and its construction and expansion joints, drainage and waterproofing, should be designed together, considering their separate and combined functions, so that each will help secure a waterproof structure.

If any necessary feature is overlooked, it may be difficult, if not impossible, to provide a remedy after trouble appears.

4. Due regard should be had for available methods and materials of construction.

Traffic conditions, climate and prevailing markets or supplies, might thus control the design. Wherever possible, waterproofing under traffic should be avoided.

5. All waterproofed surfaces should be easily accessible, and as simple and smooth as possible; hence features should be avoided which would increase the difficulty of securing waterproof construction, such as open spaces, joints, holes, seams or projections.

Deck bridges lend themselves more readily to successful treatment than the through floors, or through bridges.

6. Concrete bridge floors should be of ample strength and thickness and of dense, non-porous construction.

Special attention should be given to providing the correct amount and disposition of the reinforcement, and to securing the proper amount of water used in mixing.

7. Where contraflexure would injure the waterproofing, special details should be provided, such as elastic joints.

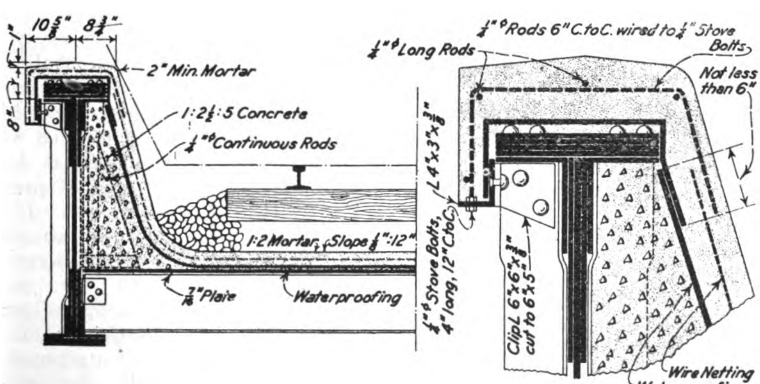

FIG. 2. CARRYING THE MEMBRANE OVER THE TOP FLANGE ELIMINATES T·
JOINT BETWEEN MEMBRANE AND WEB.

8. Minimize the number of construction joints in the structure, provided an ample number of workable expansion joints can be introduced.

Concrete bridge floors should, where practicable, be built in one continuous operation for each track.

9. Adequate drainage should be provided by means of suitable grades which will shed water by the easiest or most direct route. One per cent is a minimum desirable grade, but the grades away from points which are difficult to waterproof, should be correspondingly increased.

10. Avoid pockets which cannot be easily drained.

Water with only a slight head may find an outlet through waterproofing, which otherwise might be tight. Standing water is undesirable on a waterproofed bridge floor, from its destructive effect both as a solvent and also on account of frost action.

11. Where gutters or pipes are necessary, they should be of durable material, of ample size, easy of access to install and maintain, and protected against clogging or damage.

The grades should be enough to secure quick and entire escape of the water. Corrugated metal pipes are satisfactory where exposed to alternate freezing and thawing. Where sudden considerable variations in temperature occur, it is not desirable to encase drain pipes in concrete. Cleanouts and manholes should be provided where pipes cannot be cleaned otherwise.

12. Provide free exits for the harmless escape of drainage.

Such drainage should not be allowed to disfigure the structure nor to injure persons or property. Icicles may be prevented by a basket of rock salt inserted in the top of the drain pipe.

13. Avoid features which would induce or permit capillary action.

For example, where the waterproofing extends up under the top flange, or beneath a flashing angle, it is very desirable to make the water drip off the edge, rather than to allow it to follow the under surface and be drawn into the crack.

14. Where possible, locate edges and joints above the highest probable water level.

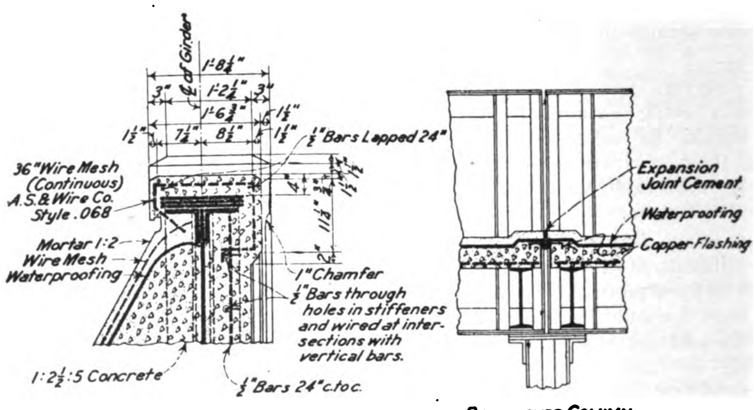

FIG. 3. ENCASEMENT OVER TOP FLANGE ACTS AS AN AUXILIARY TO WATERPROOFING MEMBRANE.

Edges of the waterproofing, either at parapets or where it joins the webs of through girders, should be at least as high as the base of rail, and preferably higher than the top of rail. Joints in the floor should be located so that the grades slope away from the joint.

15. Reinforcement of the structure should be suitably disposed, and ample in strength to prevent cracks or distortion which would injure the waterproofing.

Reinforcement should be protected against destructive agencies such as electrolysis, brine, etc.

16. Cloths, felts or fibers should be

capable of holding the waterproofing pitch where placed and should be durable, strong and flexible.

17. Wire mesh or sheet metal reinforcement for the membrane should be of durable material, flexible where necessary, and intimately bonded or introduced so that the waterproofing and reinforcement act together.

18. Necessary breaks in the surface of waterproofing or flashing, such as for drain pipes, should be reinforced with extra flashing material.

19. Flashing should be of durable material, sufficiently elastic and strong for the particular duty to be performed, and effective in the position where used. Sheet copper is recommended where theft is improbable.

20. Flashing should be of material which can be readily applied, and should

(b) Plain or reinforced cement mortar.
(c) Plain or reinforced concrete.
(d) Bituminous mastic.

For surfaces with considerable slope, mastic is not satisfactory, being difficult to apply and to retain in place.

Typical plans showing present day practice follow:

Figure No. 1 is a through plate girder having a transverse I-beam floor with concrete deck. The concrete flashing extends part way up on the web of the girders to protect them from the ballast. The joint between the concrete and web is waterproofed by means of "V" shaped recess which is sealed with an asphaltic cement. This joint is the point most apt to leak. This type requires a concrete protecting course.

Figure No. 2 shows a through plate girder span having a floor of transverse

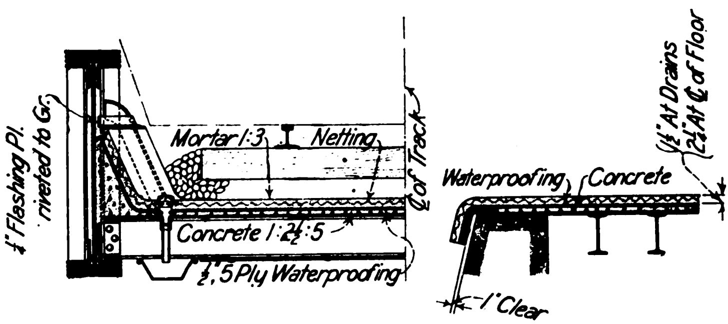

FIG. 4. A FLASHING PLATE RIVETTED TO THE WEB IS BENT DOWN OVER THE UPPER EDGE OF WATERPROOFING MEMBRANE.

retain the position in which it is placed when subjected to actual conditions of service and temperature.

21. Flashing should be firmly attached n its proper position, so that it cannot be easily displaced or removed.

22. The edges of waterproofing and flashing should be protected against drip, percolation and capillary action.

23. Waterproofing and flashing should be protected against mechanical injury, excessive temperature, chemical action, or the deterioration caused by exposure o light and air.

24. The protecting covering should be dense, hard, durable and easy to apply.

It is recommended to use on flat surfaces either:

(a) Brick laid in cement mortar or ot pitch.

I-beams with a concrete deck. In this case the waterproofing and concrete protection coat are carried over the top flange to eliminate the joint between the concrete and the web. The membrane is brought up and the other membrane is lapped outside of it in order to shed the water.

Figure No. 3 shows a similar construction having the waterproofing coming up under the top flange. In this case it is extremely important to reinforce the encasement over the top flange to prevent cracking. Note the recess in the concrete to keep the water from following the surface of the concrete, and in detail over column bent note the raising of the concrete to prevent flow of water into the opening. The main difficulty with this type is that the concrete may crack

and allow the water to come down and follow the steel. It is very important here to have the top heavily reinforced.

Figure No. 4 shows another method of joining the waterproofing membrane to the web. It consists of riveting bent steel plates to the web and carrying the membrane under this flashing. The practice of keeping the concrete deck away from the web is growing, where the area underneath the structure does not need protection. This is shown in Figure No. 5. It avoids the difficult joint between the concrete and web and insures the proper maintenance of the steel in the girders.

Plans showing waterproofing of deck steel structures having concrete decks are shown in figures No. 6 and No. 7. Fig. 6 is a type having a brick protection course. Note the detail at expansion joint and drain opening. In Fig. 7 there is a center drain between tracks.

The waterproofing of a reinforced concrete subway is shown in figure No. 8. The drainage is carried back of the abutments into tiling which carry the water into sewers. Fig. 8A shows the same scheme with two tile drains at each abutment. Note the easy slopes at the ends of both of these subways.

Figures No. 9, 10 and 11 show the waterproofing and drainage of the flat slab viaduct of the C. B. & Q. R. R. in Aurora, Ill. The slopes toward the drainage inlet are about one percent. Panels are about fifty feet long. Fig. 10 gives the details of the drainage inlets showing the recess in the casting for the waterproofing membrane. Fig. 11 and 11A give the details of waterproofing the expansion joints. Notice the notch or recess near the top of the parapet. The membrane is brought up into this recess. Where the membrane is carried over the expansion joint extra protection is provided by an iron plate.

Fig. 12 shows the waterproofing of a ballasted, creosoted timber deck subway. The concrete filler over the abutment is given a gentle slope to avoid sharp bends in the waterproofing membrane.

Fig. 13 is a part of a through girder span having a ballasted timber deck. The waterproofing membrane is laid on top of the timber and brought up on the fender, over which is placed a piece of galvanized iron bent down so as to shed water on top of the membrane. One-inch shiplap boards are laid over the membrane and held down by strips placed at the ends and nailed to the fender in order to avoid driving any nails vertically through the membrane.

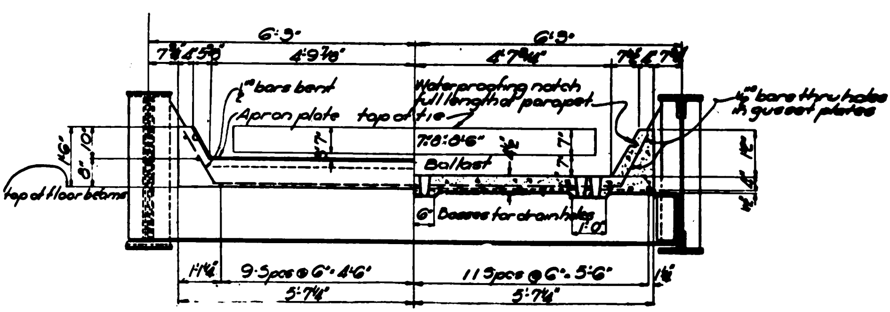

FIG. 5. LEAVING A SPACE BETWEEN THE WEB AND END OF DECK ELIMINATES A TROUBLESOME JOINT.

The qualities of waterproofing materials and their application are covered in the following specification. The range of values given is quite wide where there is not a general agreement as to properties.

Fabric

1. The cloth shall be woven cotton fabric not less than 36 in. average width with a thread count of not less than 18x18 nor more than 36 x 36, and weighing between 3½ oz. and 5 oz. per sq yard. The fabric shall be thoroughly saturated at the factory with not less than two times its own weight of bitumen which shall conform to the specifications and be of the same manufacture as that with which it is applied.

2. No oils or other bitumen solvent-

shall be used in the process of manufacture, but the saturation of the fabric shall be accomplished by pressure. This method of saturation and the weave of the fabric shall be such that the pores of the fabric are not sealed thereby.

3. The tensile strength shall not be less than 50 lb. per inch of width, grab method and stretch shall not be less than 10% before fracture.

4. Treated fabric shall be flexible at all temperatures between 0°F. and 250°F., and not flake or crack when bent back on itself. It shall be of such a nature as to conform readily to any unevenness in the surfaces to which it is to be applied, leaving no pockets, bridges or air holes. It shall be easily bent into and over corners, without injury. It shall not be coated or covered with talc, wood pulp or other substances which will tend to prevent a close permanent adhesion between successive layers or between the fabric and the plying cement.

Asphalt

5. Plying cement shall be asphaltic bitumen derived from straight refined natural asphalt, refined by direct heat without the addition of any fluxing or other material during any stage of the manufacturing process.

6. It shall have a melting point of not less than 150° F. and not more than 175° F., ball and ring method.

7. The penetration at 32° F. shall not be less than 12, at 77° between 25 and 35, and at 115° F. not more than 100.

8. It shall have a ductility at 77° of not less than 25 centimeters, and at 40° not less than 4 centimeters.

9. The loss in weight after heating at 325° for five hours shall not be more than 5/10 per cent. The penetration after such heating shall not be less than 90% of the original penetration.

10. The specific gravity shall be greater than one.

11. It shall be soluble in carbon disulphide to the extent of at least 99.5%.

12. The flash point shall be greater than 450°.

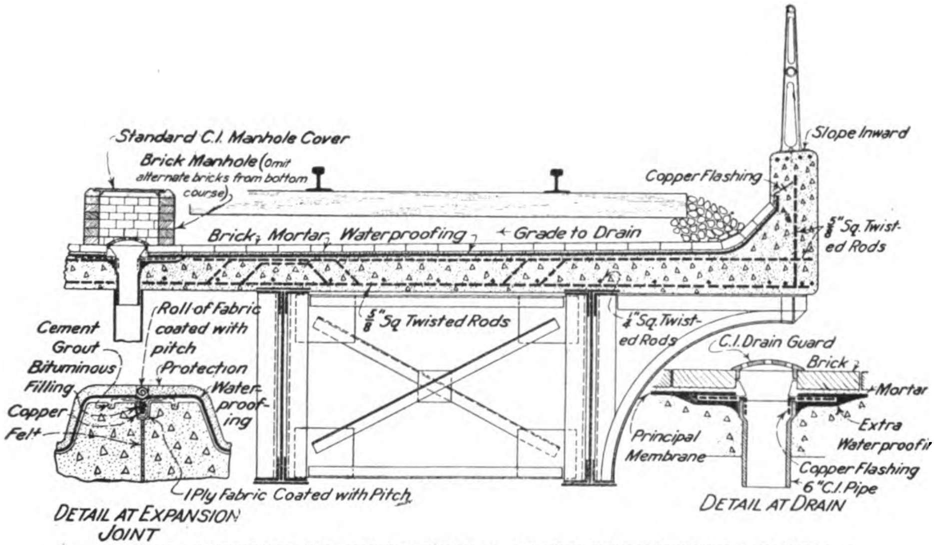

FIG. 6. METHOD OF INSTALLING A BRICK PROTECTION COURSE.

13. It shall form a permanent tenacious, mechanical bond to the membrane and to the concrete or other solid to which it is applied.

14. It shall be chemically inert, and impervious to and unaffected by water or by alkalies in cement or by acids in cinders.

15. All values specified above shall be determined according to laboratory methods outlined by the American Society for Testing Materials.

16. All materials shall be delivered on the work in the original packages, plainly marked by painting or stamping the manufacturer's brand or label on the drum.

Elastic Cement

17. Where shown on plans or specified, a pocket of ready mixed elastic cement shall seal edges of the waterproofing coat against adjoining surfaces of concrete, steel, etc., which shall be first prepared as specified in paragraph No. 34, and shall be of the same manufacture as the waterproofing material.

18. Elastic cement shall be as permanent and dependable as the other parts of the waterproofing coat. Ingredients composing elastic cement shall not have an injurious effect on materials to which it is applied. Its volume shall not be reduced by exposure to the weather, but it shall be physically and chemically stable and unaffected by water, or acids or alkalis in the solids it cements. It shall form a complete and permanent bond with adjacent material of whatever character, and form a joint that is impervious to water, yet shall yield under movement of these solids without breaking.

19. It shall be applied without the use of solvents, and at ordinary temperatures, will not be heated above 350° F., and shall be equally applicable to horizontal or vertical surfaces.

20. At all temperatures it shall be flexible, pliable, plastic and ductile, and shall be elastic at 0° F. and at 120° F. It shall show no creeping when applied one-quarter of an inch thick on a vertical surface.

Coal Tar Pitch

21. Coal tar pitch used in the waterproofing applications shall be the straight-run residue obtained from the distillation of coal tar and shall conform to the following requirements.

22. Melting point, as determined by the cube method in water bath, between 130° F. and 140° F.

23. A briquette of the material having a minimum cross-section of one square centimeter shall have a ductility of not less than 40 c. m. at 77° F. when elongated at the rate of 5 c. m. per min.

24. When a 20 gram sample of the material is heated for 5 hours at a temperature of 325° F., the loss in weight shall not exceed 7 per cent.

25. The specific gravity at 77/77° F. shall be not less than 1.24 nor more than 1.34. The specific gravity of the distillate to 670° at 140/140 F. shall be not less than 1.06.

26. Not less than 65 per cent nor more than 85 per cent of the pitch shall be soluble in hot toluol-benzol.

27. The ash shall not exceed one per cent by weight.

28. The methods of testing shall conform to those recommended by the American Society for Testing Materials.

Saturated Felt

29. Felt shall be made from woolen and cotton rags, and before being delivered on the work, shall be thoroughly treated and coated with bitumen meeting the requirements of Articles 5 to 16 and 21 to 28 inclusive, and of the same material as that with which the membrane is to be applied, except that the layer of cotton fabric specified shall conform to the requirmeents of Articles 1 to 4 inclusive.

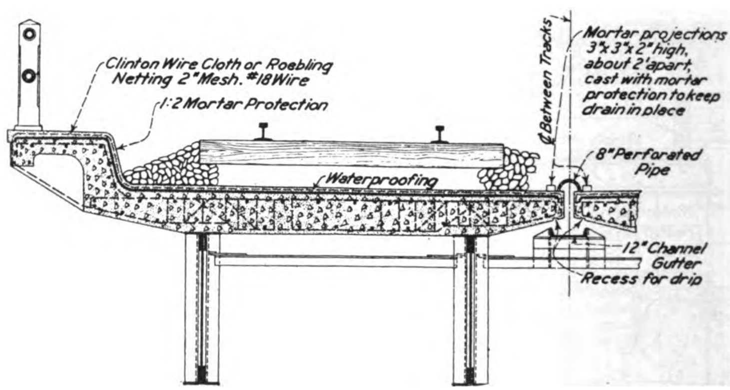

FIG. 7. EASY SLOPES LEAD TO THE CENTER OPENING BETWEEN TRACKS.

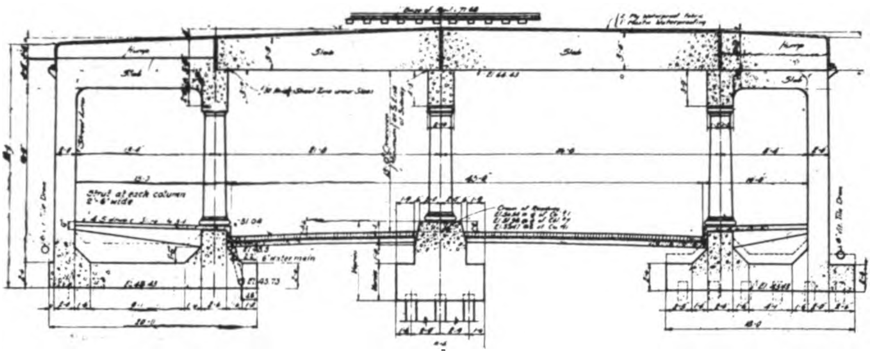

FIG. 8. DRAINAGE IS CARRIED TO TILING ON THE ABUTMENTS OF SUBWAYS.

30. The treated felt shall weigh not less than 14 lbs. per 100 sq. ft.

31. The surface of the felt shall present a smooth, finished appearance.

32. The ash of the untreated felt shall not exceed 7 per cent by weight.

Bitumen Used in Treating Felt

33. The bitumen used in treating felt shall not be liquified by oils, petroleum residue or other bitumen solvent, but by heat alone, and the treatment shall be accomplished by pressure.

Preparation of Surfaces

34. Surfaces of concrete and steel to be waterproofed shall be smooth and free from projections which might injure the waterproofing membrane. They shall be thoroughly dry so as to prevent formation of steam when the hot waterproofing materials are applied. Should these surfaces become temporarily damp before the waterproofing is applied they shall first be covered, with a layer of hot sand which shall be allowed to stand from one to two hours after which the sand shall be thoroughly removed, uncovering sufficient surface to proceed with the work, or the surface shall be dried by swabbing it with gasoline and setting fire to it. The surface of the concrete or steel in contact with the waterproofing shall be thoroughly cleaned of dust, dirt, loose particles and grease. The use of hand bellows is recommended for cleaning loose dust and dirt from the surface and from expansion joints. For cleaning grease from the steel and freshening the surface of asphalt where a junction of old and new is to be made or where a pocket of elastic cement is used against the girders and the fabric or mastic, gasoline shall be used, either by swabbing the surface with it, or pouring a small quantity over the surface to be cleaned and setting fire to it. A blow lamp may be used.

Workmanship

35. No waterproofing shall be done in wet weather or at a temperature below 40° F. without special orders from the Chief Engineer. The felt or fabric shall be laid shingle fashion with the specified number of plies, and with the top ply lapped 2 in. over the bottom. Each strip shall be laid into a mopping of hot bitu-

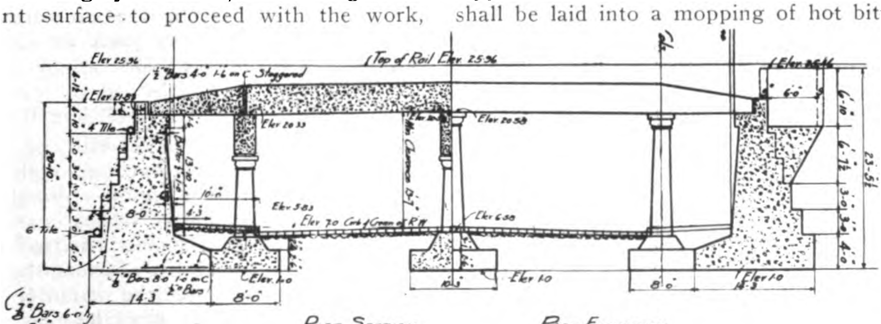

FIG. 8A. TWO DRAINS ARE INSTALLED ON EACH ABUTMENT.

men, and when the specified number of plies have been laid, the entire surface shall be mopped. The laying of the strips of felt or fabric shall start at the lowest part of the surface being waterproofed where possible. Care shall be taken to see that all parts of the surface on which a strip of felt or fabric is to be laid are completely covered with a heavy mopping of bitumen before the strip is put down, and that there are no air bubbles or pockets, or spots where the surface shows through. Where fabric is used this mopping of bitumen shall be sufficient to fill the open meshes in the fabric when it is pressed down. As soon as a strip of felt or fabric is in place it shall be pressed into the hot bitumen so as to eliminate all air bubbles. Any creases in the fabric shall be carefully pulled out smooth. Top mopping or glaze coat should be applied in such a manner and of such thickness as to completely seal and cover fabric or felt.

36. Special care shall be taken at all laps to see that they are carefully and thoroughly sealed down. The waterproof blanket shall be continuous and unbroken. Work shall be so regulated that at the close of a day, the fabric that is laid shall have been given the final mopping of plying bitumen. Where it is necessary to make joints, the laps shall be at least 12 inches.

37. Not less than 4½ gallons of bitumen shall be used for one mopping of 100 square feet of surface. Care shall be taken to avoid overheating the bitumen. Kettles shall be equipped with thermometers and the kettle temperature of asphalt must not exceed 350 degrees just before being placed in the work and for pitch 250 degrees.

38. Joints between the concrete and other material shall be grooved and filled with an elastic expansion joint cement.

39. The waterproofing membrane shall be turned down into the drainage castings without a break.

40. Special care shall be taken to make the surface waterproof along the girders, at the ends of the girders, and at stiffeners, gussets, etc.

41. Waterproofing and flashing shall be protected as soon as possible after installation against mechanical injury, excessive temperature, chemical action and deterioration caused by exposure to light and air.

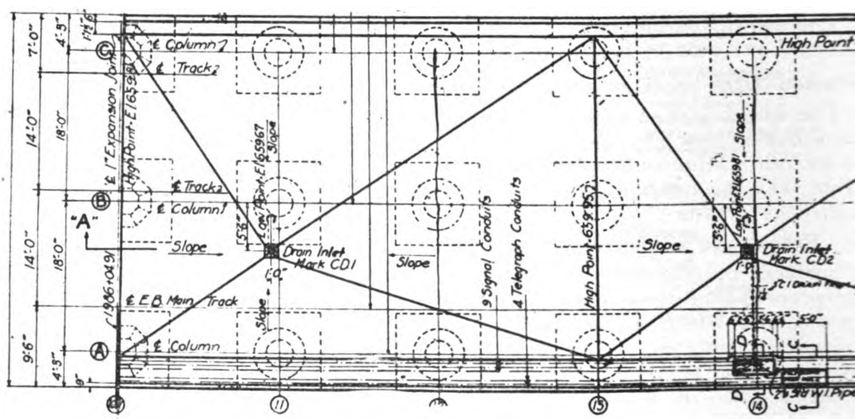

FIG. 9. GENERAL PLAN OF DRAINAGE OF AURORA TRACK ELEVATION.

Protection Course

42. Over the waterproofing membrane thus formed shall be laid a protection course of asphalt mastic, brick or concrete as specified on the plans.

(a) Concrete Course

43. The concrete course shall be a 1; 2½; 5 mix, not less than two inches thick, reinforced as required by the plans. The maximum size of the coarse aggregate shall be ¾ inch. The re-inforcement used shall have not less than a two-inch mesh and shall be of not less than No. 14 gauge. It shall be placed midway in the layer of concrete. The

top surface shall be made true to grade and shall be troweled to a smooth finish.

(b) Brick Protection Course

44. Over the waterproofing layer shall be laid a protection course of brick, except around the drainage castings on vertical surfaces, and in other locations as indicated on the plans, where concrete as specified for concrete protection shall be used.

45. The brick shall be dense, hard burned, of uniform size and quality, with square corners and free from warp and shall not increase in weight more than 10 per cent, when immersed in water for 7 hours. They shall, unless absolutely dry, be heated before laying to drive off all moisture.

46. The brick laying shall closely follow the waterproofing and the joints shall be filled immediately thereafter. The bricks shall be laid on a thin bed of dry Portland Cement and sand mixed in the proportion of 1.1. Unless otherwise specified the joints shall be filled with the same kind of bitumen used for the waterproofing. The bricks shall be dry when the joints are filled.

Mastic Protection Course

47. Where asphalt mastic protection is used a layer of waterproof paper shall be placed on top of the waterproofing membrane, over which shall be placed a protection course of bituminous mastic not less than 1½ inches thick. The paper used shall be a waterproof insulating paper 36 in. wide and weighing not less than five pounds per 100 sq. ft. The bitumen used in the mastic shall be of the same quality as that used in the waterproofing, excepting that the melting point shall be between 165° F. and 190° F., and the ductility at 77° F. shall not be less than three centimeters. The aggregate used in the mastic shall be:

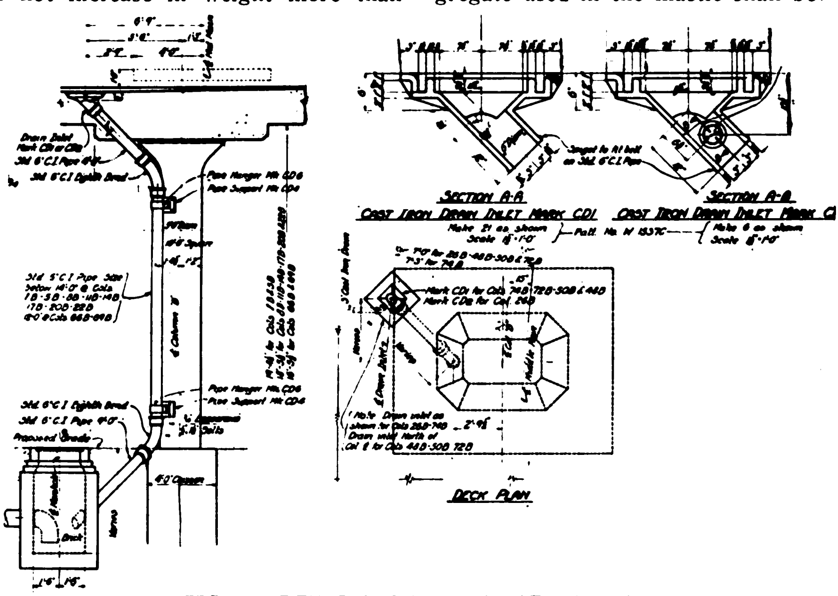

FIG. 10. DETAILS OF DRAINAGE INLETS.

48. 1—Well graded, washed gravel, containing all the material which will pass a ⅜ inch screen and will be held on a ⅛ inch screen.

2—Washed sand, free from soft particles and organic matter, containing all the material which will pass a ⅛ inch screen.

3—Portland cement or limestone dust.

49. The mastic shall contain the following percentages of the material by weight:

Bitumen	11 per cent
Gravel	38 per cent
Sand	35 per cent
Cement or Limestone dust	16 per cent

50. The bitumen shall be heated to a temperature of 350 degrees F., if asphalt is used, and to a temperature of 300 degrees F., if pitch is used, and the aggregates shall be mixed in the proportion given above and heated. After heating, the aggregates shall be placed on top of the melted bitumen in the kettle and the ingredients thoroughly mixed with iron stirring rods, until all the particles of the aggregate are covered and incorporated with the bitumen, care being taken to prevent the bitumen burning in the bottom of the kettle. After properly mixing the mastic, it shall be removed from the kettle in buckets or wheelbarrows, and shall be poured while hot. It shall be placed in layers not more than ¾ inch thick, the thickness of the layers being gauged by wooden strips held in position by suitable weights. The layers shall be so placed that they will lap joints not less than six inches and shall be spread to the proper grade and level with wooden spreaders and floats. On inclined surfaces steeper than ¾ inch, vertical to 2 in. horizontal the mastic shall be replaced by a brick or concrete protection coating. As soon as the top layer of the mastic is finished, it shall be given a mopping of hot bitumen, which shall be sanded to a walking surface while still hot.

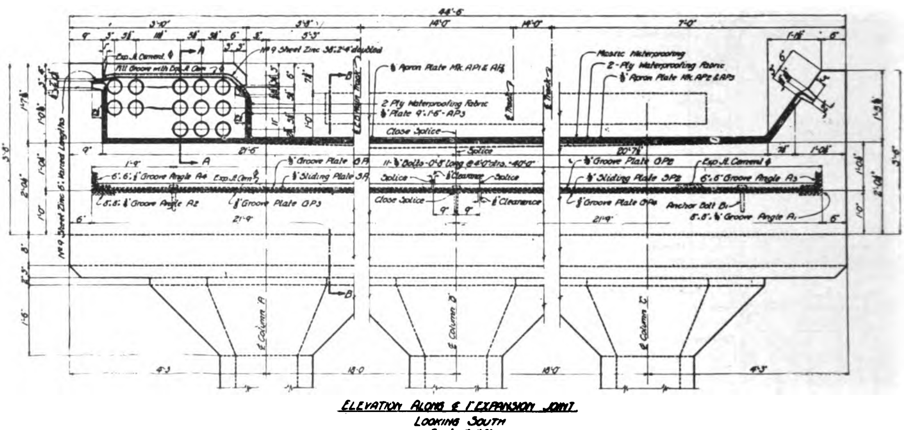

FIG. 11. ELEVATION ALONG EXPANSION JOINT.

Time for Materials to Harden

51. Sufficient time shall elapse between the placing of concrete or mortar, and the placing of waterproofing to permit the underlying material to become thoroughly hard and dry. Painted surfaces shall have set hard to the touch before concrete or mortar is deposited upon them.

Railroad traffic shall not be operated over waterproofed surfaces until the last concrete or mortar deposited is at least seven days old, without special permission from the Engineer.

Workmen

52. None but competent workmen, especially skilled in the kinds of work herein specified shall be employed.

Inspection of Materials

53. The contractor shall deliver the materials to be used in the waterproofing at the bridge site, at least three weeks in advance of the time when they are to be applied in order that they may be tested and analyzed. No work shall be started until the materials have been accepted by the Engineer.

Acceptance Tests

54. As evidence that at the time of bidding he is producing a material of the quality specified, each bidder shall submit with his bid a sample and test of the material he proposes to furnish; which test, made by an independent authority, shall cover every requirement of the specification.

55. When the material is delivered on the work, the engineer shall take from

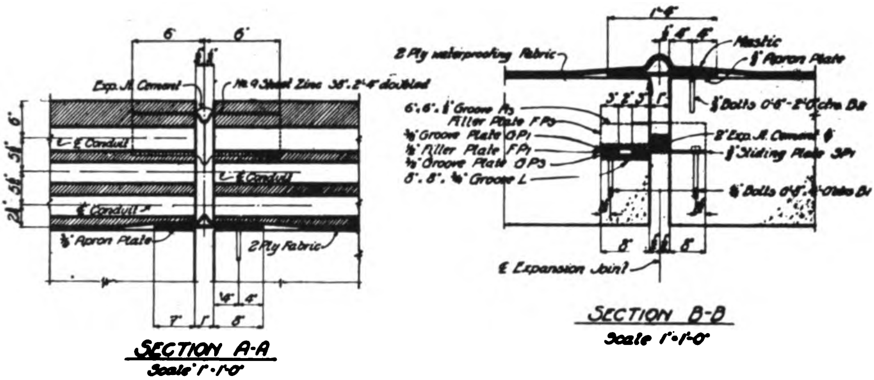

FIG. 11A. DETAILS OF EXPANSION JOINT SHOWING PROTECTION FOR MEMBRANE AND ELASTIC CEMENT.

the shipment at random samples of material, which samples he shall have tested by acceptable authority. Should the test show the material to be below specification requirements, the bidder shall remove it immediately from the work at his own expense.

56. Asphalt shall be tested at source of manufacture and when delivered on the job, each drum must bear seal of testing laboratory, the seal numbers to correspond with test reports submitted by testing laboratory.

One of the disputed points is the number of threads per inch in woven cotton fabric and the strength of the same which latter depends in a general way on the number of threads. Some advocate a small number of threads and less strength to get an open weave to allow thorough amalgamation of the successive moppings of bitumen. Others advocate a closer weave and higher strength, claiming that it is open enough to secure proper bonding.

The value for the ductility of asphalt is another question which is a compartively new one, great advances having been made in recent years in the increase in ductility of this material.

Advantages are claimed for cotton fabric over felt due to its being more pliable and more easily fitted to corners and bends without breaking. It is also easier to prevent air pockets from being formed under cotton cloth due to its porous nature. On the other hand, felt itself resists the passage of water, to some extent.

Pitch has the disadvantage of becom-

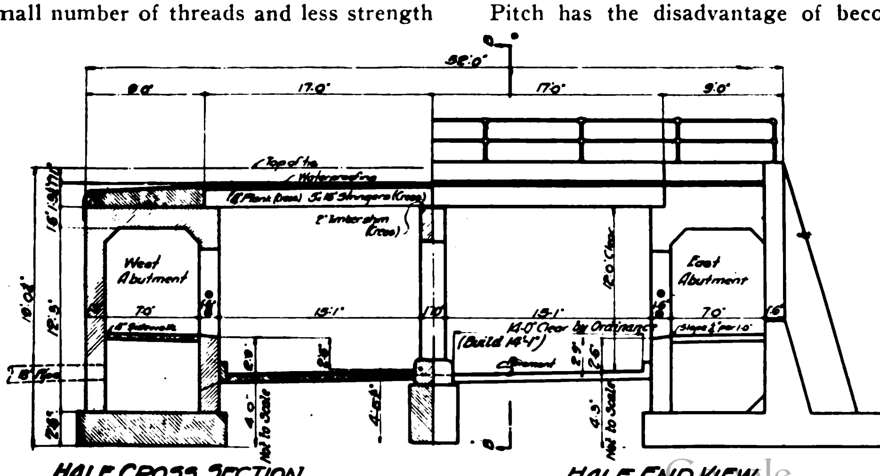

FIG. 12. BALLASTED TIMBER DECK SUBWAY WITH CONCRETE FILLER OVER SIDE-WALK SLAB.

ing brittle in cold weather and it would seem advisable to use it only where it is protected from extreme changes in temperature and vibration. It should not be used on surfaces having steep slopes where temperatures are high enough to soften it.

The kind of protection course used depends on the headroom available, the asphalt mastic taking up the least space but costing somewhat more than brick or concrete.

In order to outline the progress of bridge waterproofing and point out examples of failure, as well as success, I will review this work as it has been carried on, on the C. B. & Q. R. R. during the time I have been connected with it. This is probably representative of the work on other roads who have taken an active interest in the subject.

The first big problem came up in connection with waterproofing the decks of our Chicago Track Elevation Bridges which consisted of concrete slab units as shown in figure No. 14. An attempt was made to waterproof only the joints between the slabs, and seven different methods used are shown in figure No. 15. None of these was successful because of the vibration in the slabs and the impossibility of retaining the waterproofing bitumen in the joints.

The membrane method was then adopted as shown on the right-hand side of figure No. 16. At first three and then five layers of untreated burlap with asphalt bitumen were used. This was protected with 1-in. of asphalt and sand mastic. This membrane began to leak soon after it was applied. It was found that the leaks were generally over the cross girders and that the membrane was ruptured at these points. There were two reasons:—

First. Slight settlemnt of the abutments which were not on rock foundation.

Second. Action of live load in pushing the membrane down the steep slope over the sidewalk columns. On future work the slope of this concrete filler was considerably reduced and a fold was made in the membrane to allow a slight amount of stretching by inserting a pipe under it over each cross girder when it was being laid, as shown on the left-hand side of figure No. 16.

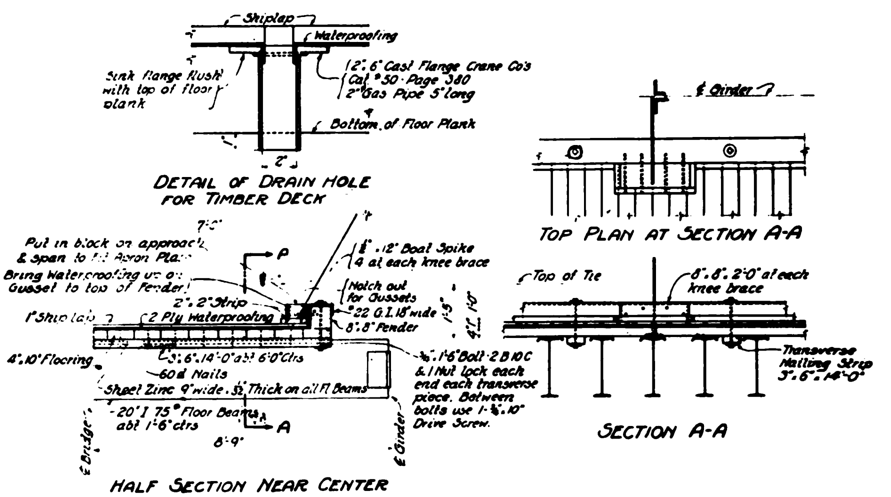

FIG. 13. DETAILS OF WATERPROOFING TIMBER DECK WITH WOODEN PROTECTION COURSE.

It was found that the burlap had begun to rot where water reached it through the cracks over the columns. It was thought that it had not been properly impregnated with asphalt. After this burlap, which had been saturated at a manufacturing plant, was used. Experiments on this material showed that it was impossible to obtain proper saturation even by plant methods. About this time sat-

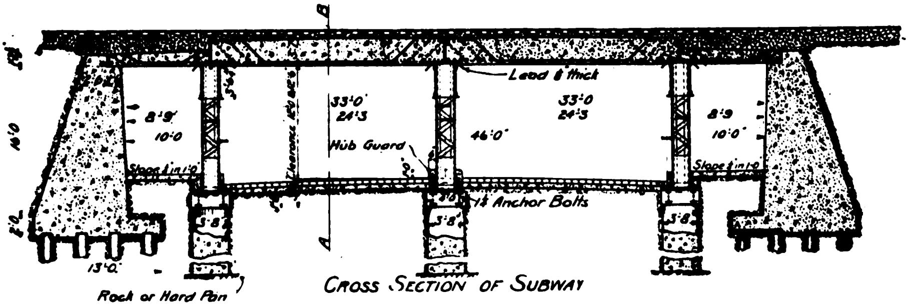

FIG. 14. EARLY TYPE OF SUBWAY USED IN CHICAGO WITH WATERPROOFING AT JOINTS ONLY.

urated cotton cloth was introduced and is the material still used.

We have used a small amount saturated with pitch, but the bulk has been saturated with asphalt. Our present standard is the use of two plies of asphalt saturated cotton cloth laid with moppings of asphalt and covered with a layer of asphalt and sand mastic.

Integral waterproofing compounds are used in some cases in bridge decks where the area underneath does not need protection, in order to prevent water from entering the concrete and cause its disintegration through chemical action, or frost. It is also used in substructures in cases where alkali waters come in contact with concrete.

Integral waterproofing, however, is not suitable for waterproofing concrete which is liable to crack as is the case in bridge decks where considerable vibration takes place, nor for unit construction or work having construction joints.

SUMMARY

The membrane method of waterproofing has been generally adopted for railroad bridge decks.

Waterproofing is used for two reasons:—

1. To prevent water from reaching a protected area.
2. To protect metal and concrete work from deterioration, especially by brine or electrolysis.

The factors affecting waterproofing shown in the order of their importance are:—

1. The proper design of the structure.
2. The proper application of the waterproofing materials.

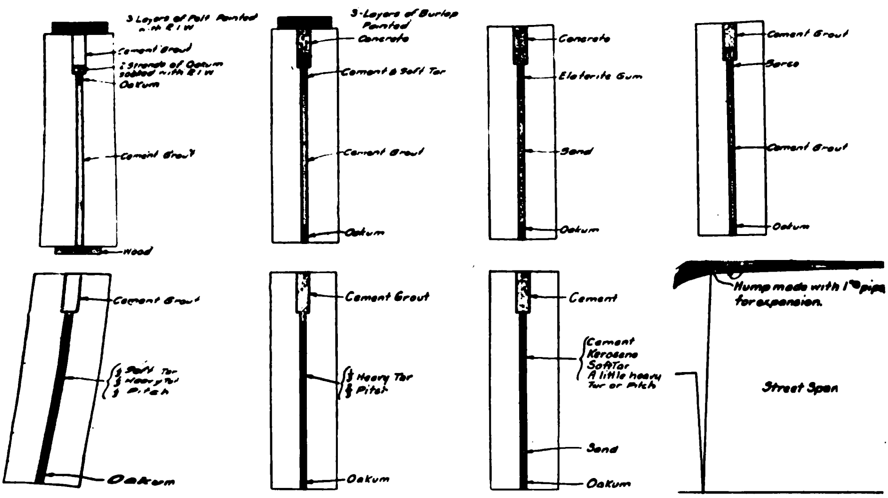

FIG. 15. SEVEN DIFERENT TYPES OF WATERPROOFED JOINTS.

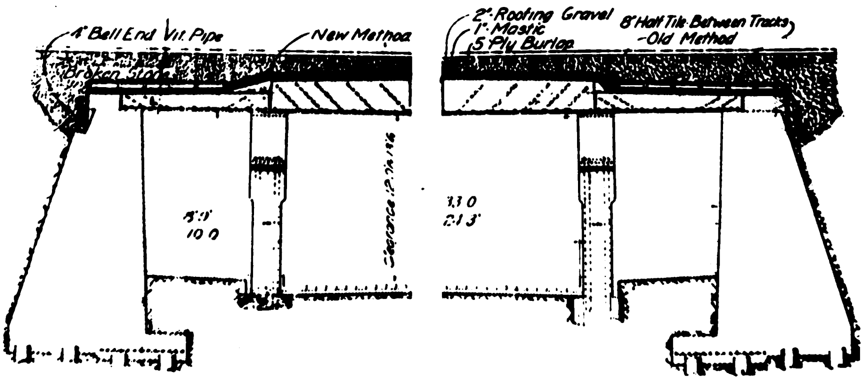

FIG. 16. OLD AND NEW METHODS OF APPLYING WATERPROOF MEMBRANE.

3. The qualities of the waterproofing materials.

The foundation for successful waterproofing lies in the design of the structure, as lack of stiffness, proper grades for drainage, proper flashing at the edges of the membrane, etc., will cause any material to fail.

The application is next in importance. Weather conditions must be good, surfaces must be smooth and clean. Care must be taken not to destroy the waterproofing qualities of the material by overheating, proper amounts of material must be properly applied, special attention must be paid to securing waterproof connections at the edges of the membrane, and the membrane must be properly protected from injury.

The materials used are the source of the widest variation in waterproofing practice. Asphalt or pitch in combination with cotton drilling or felt are almost universally used. It is exceedingly difficult to pass judgment on various materials because service tests are of so little value, the factors of design and application governing in most cases.

I do not feel that waterproofing has reached its final state of development, although very great progress has been made during the past ten years and will continue to study new methods and materials which may be developed.

I am indebted to the American Railway Engineering Association and Railroad Companies for the use of some of the illustrations used in this paper.

Automatic Substations in Steel Mills

By G. P. Wilson*

Presented January 26, 1925

This paper gives the general characteristics of some automatic substations recently installed in steel mills. It would be impossible to go into all the intricate details in a short article. The stations are designed to perform certain operations more accurately than if operated by hand and to use better judgement than most operators. Savings in labor of attendance and less interruptions to service are reported.—Editor.

A COMPARATIVELY few years back saw the first automatic substations put into operation. These initial installations were for small isolated equipments, very plain and simple in their construction and operation. They were watched with considerable interest by those who were responsible for their installation and successful operation. They proved to be reliable and a few more units were added and the demand grew until at the present time it has reached a proportion almost equal to that of the manually operated equipment.

Similar to their growth, their field of application increased. Today the automatic substation is found in practically every branch of the electrical industry. It is logical too, that this should occur because the basic principle governing the application of automatic switching equipment is the same in all industries.

Economy is the principal reason in most cases for their installation. It is quite natural with the adoption of the eight-hour day in the steel mills that the steel-mill engineer would wish to investigate and install in his plant every safe, sound and proven device which would reduce labor cost, improve operating conditions and increase production. The automatic substation, we know from experience, will accomplish these results. I am sure that engineers who have had experience with the automatic substation in the railway, mining or central station field will bear me out in the statement that the automatic substation is one of the greatest labor-saving devices that has been developed in the electrical field in the past decade.

Hundreds of installations have been made and are operating sucessfully in the street railway, mining and central station fields and a few in the industrial field such as automobile plants and steel mills.

The past year has seen two outstanding installations made in the steel mills. One of these installations is at the Lackawanna plant of the Bethlehem Steel Company at Buffalo, N. Y., and the other installation is at the Edgar Thomson Works of the Carnegie Steel Company at Braddock, Pa. Both of these have been installed several months. Neither of them, however, has operated a sufficient length of time to give a thorough test or check on all the relays and protective devices. We have found from experience that an automatic substation seldom functions perfectly when first put into operation. This failure may be due to improper adjustment of the relays for load conditions, or to old apparatus which has been retained in the substation or to contact adjustment on the relays. We have met with a number of unexpected problems in the Carnegie Steel installations. For example the reversal of power under certain load conditions, due to engine-driven units connected into the D. C. network. These engine-driven units do not have voltage regulators and in addition the engine governors are slow to act, making the machine very sluggish and slow to respond to load changes. Therefore, the automatic units which have regulators and respond very quickly to changes in load, are unable at times to maintain correct power relation. The solution to the problem will be to add regulators to the engine-driven units. This trouble was anticipated at the Lackawanna installation and regulators were provided for the manually operated units in the principal

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The installation at the Carnegie Steel plant is the largest automatic switching equipment that has ever been made in the steel industry. Three substations have been changed from manually operated to complete automatic. These installations comprise all of the substations in this plant. Their main power house is equipped with the engine-driven units mentioned above and one 1500-Kw. motor generator set. These units are still manually operated and inasmuch as they are located in the main power house, will probably never be changed to automatic control. The substations. that were changed are known as their No. 1, No. 2 and No. 3 substations. Station No. 1 is shown in Fig. 1, and as indicated has two 1000-kw. motor generator sets, two incoming 3-phase, 6600-volt lines, a feeder to a 1500-kw. transformer bank located in the station. This transformer bank is used for supplying power to the A. C. motors in the open hearth plant, the blooming mill and No. 2 mill.

Operates from Either System

It is very important to maintain A. C. power on these feeders so as to keep the open hearth gas producers going and the A. C. auxiliary motors for the mill tables and other devices. There are times when the alternating current in this plant fails, leaving nothing but D. C. power supplied by the engine-driven units located in the D. C. power house. One of the machines in this station is arranged, therefore, for automatically inverting and operating through the D. C. end as a direct-current motor and the A. C. end as an A. C. generator and supplying A. C. power to the transformer bank, thus maintaining service on these important feeders. The relays function in response to alternating current interruption, and either start the machine from rest as a D. C. motor if it happens to be down at the time A. C. power fails, or inverts it and operates it from the D. C. system. One of the relays cuts in a frequency regulator which takes control of the direct current machine's field rheostat and governs the speed of the set so as to maintain approximately 25 cycles. Another relay cuts in a voltage regulator which takes control of the A. C. machine's field rheostat and maintains constant A. C. voltage. Upon resumption of the alternating current supply the equipment is arranged so that the operator may synchronize his power plant with 25 cycles from the inverted motor generator set, or he can trip the motor generator set off the line, close the incoming line breaker to the substation and start the motor generator set from the A. C. end and operate it in the normal manner. The relays respond very quickly to A. C. voltage failure. They invert the machine and supply A. C. power in less than seven seconds from the time the main A. C. power goes off. The equipment is expected to reduce, if not entirely eliminate, all cobbles of steel in No. 2 and blooming mills, due to A. C. power interruption. We understand from the customer that this equipment has functioned successfully since the installation and has accomplished what it was intended to do.

No. 2 substation has only one 1000-kw. motor generator set, one incoming 6600-volt, 3-phase, line and D. C. feeder to the open hearth department. This motor generator set is not arranged for running or starting inverted.

The No. 3 substation is located near the blast furnace and is equipped with two 1000-kw. motor generator sets similar to those in No. 1 substation, two incoming lines and D. C. feeders to blast furnaces and tie to the D. C. system.

Lackawanna Station

The substation at the Lackawanna plant is known as the coke oven substation. This station has two 6600-volt, 3-phase, 25-cycle incoming lines, two 1000-kw., 250-volt, D. C. motor generator sets, one 6600-volt, 3-phase, 25-cycle feeder to auxiliary power transformer bank, 2000-kva., 6600/4400-volt, two 440-volt, 3-phase, 25 cycle, A. C. auxiliary.

All of the circuits both A. C. and D. C as well as the control for the machines are full automatic. The machines are arranged for starting on load demand and automatic stopping on underload. The A. C. circuits are equipped with periodic reclosing relays that close the breakers two or three times if they come open due to failure of power or short circuit, or heavy overload which causes them to open. The D. C. feeder circuits are provided with short circuit detectors and

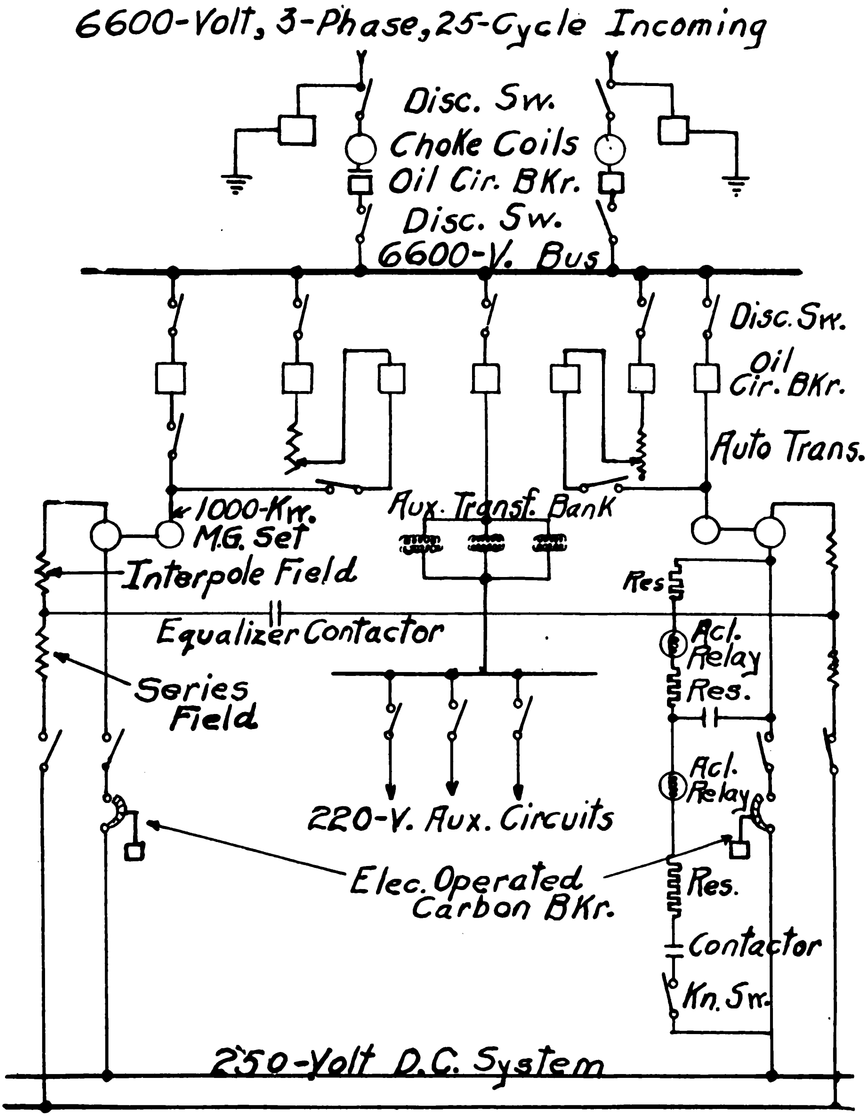

FIG. 1. SCHEMATIC DIAGRAM OF CONNECTIONS OF TYPICAL AUTOMATIC SUB-STATION HAVING TWO MOTOR GENERATOR SETS.

non-closable-on-overload devices which prevent the circuits from opening on heavy overload but instantly cause it to come out on short circuit and further prevent the breaker from reclosing until the short, which has caused it to open, is removed.

The starting scheme of this station is rather unique. The energizing of No. 1 incoming line energizes the relays from the 6600/110-volt potential transformers connected to the main bus causing the relays to operate in proper sequence thus putting the first machine on the line. Both machines at the Lackawanna plant start up but only one of them connects its D. C. end to the D. C. system until power demand requires the D. C. breaker on the

second machine to close. The second machine is run as a synchronous condenser for power factor correction until power demand requires it to operate as a motor generator set and supply D. C. power.

In addition to the above method of starting, the machines in all the substations at the Edgar Thomson plant may be started and stopped by push buttons located in the main power house by an operator and load indication given him for each of the machines in the substations. This load indicating and control scheme consists of a single wire control shown in simplified form in Fig. 2. This single wire scheme, as you may note from the diagram, is possible due to the direct current system network being tied into all the substations. In the main power house are a number of D. C. machines which are also tied to the network. A standard stop and start push-button switch, a single-pole-double-throw knife switch and a milli-ammeter for each substation are mounted in a place convenient for the operator. The milli-ammeter for No. 2 station which has only one machine is calibrated with one point marked on the dial, while those for No. 1 and No. 3 are calibrated with two points, one to indicate a single machine running and the other with two machines running. To start the equipment the double throw switch is closed in the lower position of its contact. The start push button is held closed for a short interval of time which completes a circuit from the negative bus to the control wire through back contacts of relay 4 and relay 3 and then through the coil of master relay 3-A to the positive bus. This closes relay 3 which starts the first machine. Relay 3, when it pulls up, opens its contacts thus cutting loose the coil circuit of 3-A from the control wire, but 3-A has a contact which when closed parallels the control circuit and connects the coil of relay 3 directly to the negative bus. The control circuit from contacts of relay 3 go to the closing coil of the main D. C. generator breaker through auxiliary relay contacts, thereby closing the generator breaker and placing the set on the line. When this generator breaker closes auxiliary contacts 12-1 which are on the breaker close, connecting the negative bus through a resistor to the control wire. At the power plant the control wire is connected to a milli-ammeter and a resistor to the positive bus. These resistors are proportioned so that the milli-ammeter pointer swings to the first mark on the dial indicating to the power plant operator that the first machine has gone into service.

The second machine is completely automatic starting on load demand. The indication to the power house operator that it has come into service is accomplished by the closing of auxiliary contacts 12-2 of the main generator breaker, which cuts a resistor in parallel with the first machine resistor causing more current to flow through the control wire and the milli-ammeter. The meter pointer then swings over to the second mark on the dial thus indicating that the second machine is in service.

Has Automatic Time Stop

The station is shut down by the operator closing the stop push button indicated in the diagram, or if forgotten by the operator, by a time relay in conjunction with under load relay. These relays prevent the set from remaining on the line over Sunday or any other extended time when no load is required. The time relay may be set for several seconds to several minutes. When the contacts of the push button, marked "stop" in the diagram, close current flows from the positive bus to the control wire to the coil of relay 4 through contacts of relay 3 to the negative bus. Relay 4 closes and holds itself in the closed position. Another set of contacts on relay 4 short circuits the coil of master relay 3-A, disconnects all control circuits from the source of supply causing the station to shut down. When the machine is shut down by the operator at the power house he immediately receives indication that it has gone out of service. The opening of the main generator breakers opens the auxiliary contacts on the breaker, 12-1 or 12-2, indicating to the operator that the machine has gone off the line. It will be noted that if the single pole switch is thrown to the "up" position that the station will be locked out of service, inasmuch as the coil of relay 4 will be

energized, holding this relay closed and maintaining a short circuit across the coil of the master relay 3-A. This operation permanently locks out the station until the knife switch is open.

Automatic Paralleling Device

No doubt most of us have, at some time during our operating days, expressed a desire to have some automatic means of paralleling an incoming generator with other machines which are connected to the bus. Each of the substations for both the Lackawanna and the Carnegie Steel plants is equipped with such a device. One panel of the switchboard is equipped with three main regulating elements for each generator in the station. The upper element is the one used for paralleling an incoming generator with existing running equipment. This regulator has one of its coils connected to the bus and the other coil to the machine. When the voltages between the bus and machine are equal, these coils are in a balanced condition and their contacts are open. When they are not equal, contact is closed in either an upward or downward position and will operate contactors located at the top of the panel which control the motor field rheostats. This regulator operates on the field rheostat and adjusts the machine voltage to the same voltage as the main bus. A time relay is connected across the contacts of the regulator which will energize when the rheostat control contactors are open. Thus whenever the machine voltage balances with the bus voltage for a period of time this time relay will close its contacts and energize the closing coil of the main generator breaker and closing it place the machine directly on the bus. The second element of the regulator comes into action when this direct current breaker is closed. Auxiliary contacts on this breaker transfer the rheostat control from the above mentioned balance regulator to this regulator which is known as the voltage element control of the equipment. This element operates on the field rheostat of the machine, raises the machine voltage to a value sufficient to load the machine properly for normal operating condition.

The third element of the regulator is a load limiting or load shifting element. This element is equipped with very low resistance coils which operate from the milli-volt drop obtained across the commutating-pole windings of the generator. The voltage element is calibrated for a certain value. Should the current which the machine is delivering exceed this value this current limiting element of the regulator will automatically supersede the voltage control and lower the voltage of the generator by operating the field rheostat, thus preventing an overload occurring on the generator. While this element is in operation the load is automatically shifted from this station to some other station. However, this regulator may be thought of as a load shifting device as well as a load limiting element for any individual generator. The voltage element and the load-limiting element will automatically supersede one another as the load condition on the machine changes. The load-limiting element will regulate the generator as a constant-current machine at some voltage below its normal operating point. However, when the load reduces below the value to which the regulator is set, the voltage element will step in and take control and regulate the machine at a constant potential.

Reclosing Features

All of the substations in these two plants are provided with periodic reclosing equipment for the A. C. circuits. The periodic reclosing relay is a motor-operated drum switch with a number of contact segments. The operation of the equipment is comparatively simple. When the breaker opens due to overload, the armature and forward-running field switch of the periodic relay motor are energized through the auxiliary switch contacts on the oil circuit breaker. This rotates the drum in a forward direction. Two holding contacts (4 and 5) close after a short period of time, due to the drum revolving, and energize the control relay through a resistor which has a value sufficiently high to prevent the armature of the relay from operating, but will hold it in, once it is closed. After short interval of time, which is adjustable, two other contacts of the relay (6 and 7) close and energize the operating coil of the control relay with full voltage. This causes it to close its main contacts which in turn energizes the closing coil of the

breaker causing it to close and latch in. When the breaker closes an auxiliary switch contact on the breaker completes the circuit to the releasing coil of the control relay. This releases a latch between the armature and the contact members of the control relay and permits the main contacts to open.

When the breaker starts to close the forward rotation of the drum is stopped due to the auxiliary switch contacts of the breaker opening the circuit of the forward-running field of the motor. If the breaker remains closed, the periodic-relay-motor-reverse-running-field contactor is energized which reverses the rotation of the motor and the drum is rotated until it reaches its original normal position and is stopped by a set of limit contacts (2 and 3). The equipment is usually provided for making three recloses. If it is unsuccessful in its three attempts to close the breaker the drum of the relay will continue forward until stopped by the opening of the limit contacts (1 and 2). This de-energizes the armature and the field of the motor in the forward direction which causes the equipment to be out of service until the breaker is reclosed from the manually operated control switch mounted on the panels.

This automatic equipment and scheme of control does not in any way supersede the automatic protective features obtained by the use of the ordinary overload relays.

Short Circuit Detector

The Lackawanna installation is provided with D. C. feeders for taking care of local circuits near the substation. These feeders are completely automatic and do things that no operator, no matter how well trained or how many years of experience he has had, can ever hope to do. The main carbon circuit breaker for these circuits will open only on a short circuit irrespective of the distance of the short from the equipment and will not open on a heavy overload, though the overload is sustained for quite a while and is several times the value of the short circuit. I am sure that the above described equipment meets the conditions which most of you at times desire for your manually operated station. This equipment is very simple and its operation accurate and dependable. A standard through-type current transformer with its magnetic circuit opened slightly to prevent saturation, is put on the outgoing feeder.

The changes of current, due to overload are relatively slow and gradual, while a short circuit produces a very rapid rise. The quick changing of current induces a current in the secondary of the transformer of sufficient magnitude to operate the trip relay and trip out the breaker while the over-load current which changes slowly even though it be much greater in value than the short circuit current, will not induce sufficient current to operate the relay.

In addition to the above performance the equipment exercises still further good judgment by preventing the breaker from closing if it comes out on short circuit until the short is removed. This is accomplished by the use of a Wheatstone bridge arrangement of resistance which measures the circuit resistance and prevents the closing relay from becoming energized sufficient to close the main carbon breaker unless the load resistance has built up to normal operating condition.

Complete Protection

The protection afforded the machines while in service in these two installations is complete. In addition to the ordinary overload, reverse power and low voltage protection usually found in the manually operated station, each of the machines in these automatic substations is provided with relays and devices which protect it against hot bearings, overheating of the machine windings, single phase operation of the A. C. and, reverse phase operation, overloading or overworking of the starting equipment, the closing of any D. C. circuit on short circuit condition, the paralleling of D. C. machines unless voltage condition is correct for their parallel operation, unbalanced load condition on any machine and the transferring of the A. C. end of the sets from start to running condition unless the machine has reached synchronous speed.

To describe the design, construction, function and operation of all the various types and forms of relays used for pro-

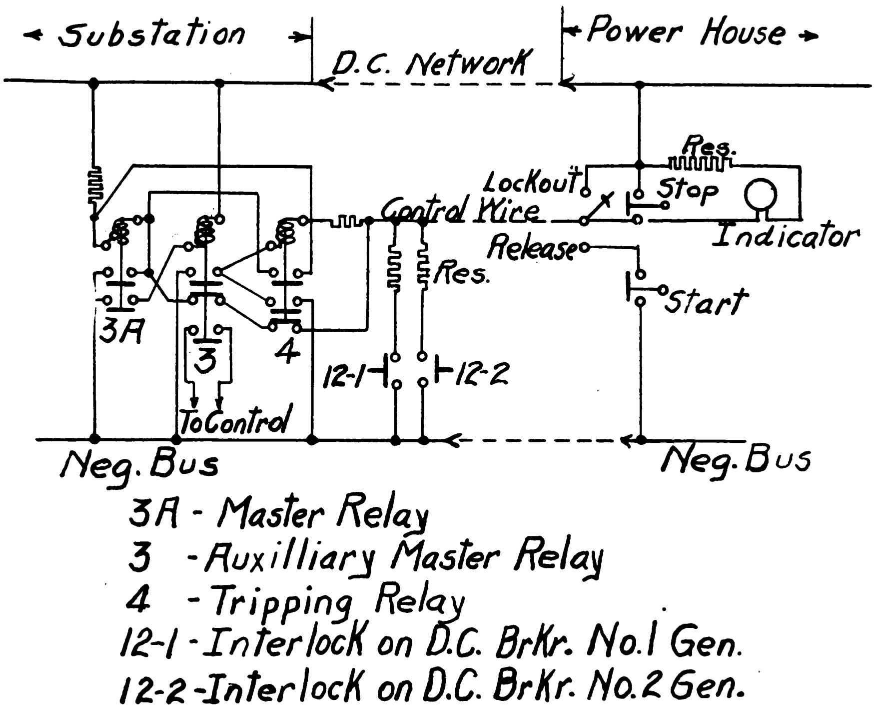

FIG. 2. CONNECTIONS OF THE SINGLE WIRE CONTROL SYSTEM FOR AUTOMATIC SUBSTATIONS.

tective purposes would be too long and of no particular value for this paper. We do feel, however, that you will be particularly interested in some of the relays that are important and protect against trouble, which is quite frequently met in the manually operated station. One of the most important and probably one of the worst troubles that must be carefully guarded against at all times is that of overheating in the bearing. Each of the machines in these installations is equipped with bearing thermostats which automatically and promptly shut down the set whenever bearing trouble developes and a dangerous temperature is reached. This device consists of a bulb connected to a copper bellows. The bulb which is probably 4 in. or 5 in. long and ⅝ in. in diameter contains a volatile fluid which has a boiling point at the temperature where the bearing metal is considered dangerous. This fluid when it boils vaporizes and the vapor forces the bellows open thus lifting a toggle switch which opens the circuit and shuts the machine down. Care must be exercised in installing this equipment. A hole is bored into the pedestal supporting the bearing and continued on until it touches the lower part of the bearing metal. The tube thus lies directly against the bearing metal and also at the bottom portion thus being located at the most likely place for bearing trouble to develop.

Another source of trouble which most of us are probably familiar with and have had occasion to worry over, is overheating of coils in the machine due to overload or some defect in the windings. All the machines are provided with thermal relays which protect them against this source of trouble. The coils of this relay are connected in the secondary of a current transformer located in the supply leads of the synchronous motor. This relay is provided with adjustment whic[h] permits accurate settings of the r

to give ample protection to the machine and at the same time permits the use of a current transformer having a standard ratio. The thermal element of the relay is mounted in an oil filled receptacle. Inside the receptacle are bimetallic spiral springs which have their inner ends mounted on the vertical shaft which extends up through the container and their outer ends anchored to the sides of the receptacle. These springs carry the current from the coils located at the bottom of the relay which are connected to the current transformer. Around the container is a jacket which retards the radiation of the heat from the outer walls. The heat from the current as it passes through the springs is absorbed by the oil. The relay is adjusted so that the input from the current transformer is just equal to the radiation of heat at full load. Mounted at the top of the vertical shaft are the moving contacts. The stationary contact is mounted at the top of the relay casting and adjustable to permit accurate setting for different time of operation.

When the input to the machine and, therefore, the input to the relay exceeds the radiating ability of the jacket the temperature of the oil rises and the bimetallic springs expand causing the shaft to rotate and close the contacts. In this way the relay operates on the actual heating current input to the machine.

Still another source of trouble which is experienced in manually operated stations is overheating of auto transformers used for starting the synchronous machines. These thermal relays may be used for tripping the starting breaker or locking it out should the transformers become over-heated from too frequent starting duty. The general practice, however, is to use the cartridge type of thermal relay for this purpose. This relay is made up of two bimetallic pieces of metal, and enclosed in a cartridge approximately the size of 60-ampere fuse and may be inserted in that size of fuse holder.

Another relay which is of very great importance on an automatic switching installation is the lockout relay which locks the station out of service should trouble develop due to any defective or primary cause, such as bearing trouble, overheating of the machines, breakdown on auto transformers or starting equipment. It is essential also that the maintenance crew be advised promptly the cause of any trouble which may lock the station out. This lockout relay, therefore, combines not only the function of locking the station out of service, but indicating what has caused the trouble. The relay has a manually reset magnetically tripped trigger. The trip circuits come into the relay through individual annunciator drops. These drops indicate that the equipment has been shut down due to short circuit occurring on the A. C. side of the machine or due to the operation of the bearing thermostats, or the operation of the time relay which is used in the starting switch connection of the machine to the auto transformers, or from open-phase trouble within the station, such as contacts in the starting switch burning off. Other indications may be placed on the relay if desired. These are the principal serious causes which the maintenance man should know promptly in case of failure of the equipment.

The economy in labor and operating costs were the principal reason for recommending the installation of automatic substation equipment in these two plants. The Edgar Thomson installation has eliminated nine operators and the Lackawanna three. To our knowledge it has not been necessary to hire experienced men to take care of these installations. We are training men from their present force to care for these equipments.

It has been found in the railway and mining field that a weekly inspection will usually maintain the equipment in good operating condition. Most of the relays, especially those of less rugged design, are enclosed in dust-proof cases, thereby requiring little, if any, attention. Practically the only parts which will wear under ordinary operation, sufficient to require replacement, are the contacts of the relays. This is also true of the breakers and larger contactors. These parts, as on any other control, will need occasional thorough inspection and no doubt replacement if trouble is to be eliminated.

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The Need for Adequate Street Lighting

By O. F. HAAS*

Presented December 22, 1924

This paper and the two following it were presented at a meeting devoted to the general subject of street lighting which has become of such great importance in recent years. Mr. Haas points out the reasons why adequate illumination of streets is an investment of economic value because of the large reduction in street accidents, 90% reduction in crime and greatly increased trade on business streets.—Editor.

FALLING of darkness may be compared to the pacing of partial blindfolds on both drivers and pedestrians; and darkness, therefore, introduces a very serious additional hazard on streets that are not properly illuminated. With the great increase of pleasure driving and trucking at night, the number of night accidents is very high and is undoubtedly increasing at a greater rate that the day accidents. Not only is it more difficult to see objects at the same distance under a dim light, but tests have shown that it actually requires an *appreciably longer time* to see under a dim light, than under bright illumination, as in the daytime, yet speed limits are the same at night as in the day.

Curves plotted from the yearly records of automobile fatalities and the total automobiles registered show that the number of accidents has increased practically parallel with the number of automobiles in use. Roughly each increase of a million automobiles in use has added 1000 to the annual death toll. In 1923, 15,500 persons were killed in traffic accidents—twenty times as many as in 1908, fifteen years ago.

What a Survey of Traffic Accidents Showed

Over a year ago, through the co-operation of individuals interested in safety, the Engineering Department of the National Lamp Works was able to complete a survey of traffic accidents in thirty-two cities in different parts of the country. These 32 cities, represent a total population of over seven million inhabitants. The purpose of the survey was to determine in a quantitative way the relation between light and darkness as regards the traffic accident hazard. The total number of street accidents for a year in these cities was 31,475, of which 9,534 or about 30% occurred during the hours of darkness. The results of this investigation indicate that it is safe to assume that 17.6% of all night traffic accidents may be attributed to lack of light. Assuming that the same proportion of day and night accidents which was found to exist in this survey holds in all cities, there must have been out of the total of 15,500 persons killed in 1923 by automobile accidents alone, 4,650 night automobile fatalities of which 17.6% or about 820 are directly attributed to lack of sufficient illumination. Accepting the rate of 26 serious accidents to each death there were over 21,000 serious accidents attributable to lack of light. On top of this loss in life and injury to persons, it may be safely assumed that of the billion dollar total damage estimated by Dr. Crum and others as resulting from street accidents $54,000,000 may be attributed to lack of light. According to census reports this is practically equal to the amount paid for street lighting of all kinds in the United States.

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It is significant to note that in various cities the percentage of accidents attributable to inadequate illumination as developed by the survey varied widely. In some cities where the need for better street lighting is especially evident the percentage of night accidents chargeable to the lack of light is likely to run as high as 50%. On the other hand, in the case of those districts where fairly high levels of artificial street lighting are provided by so-called White Way systems the percentage of night accidents chargeable to lack of illumination can be said to be fairly low.

In the City of Cleveland there are several major thoroughfares leading East on which are double track street car lines. Of these Euclid and Woodland Avenues have well designed street lighting systems from the heart of the City to 55th street consisting of 1500-candlepower (15000 lumen) and 1000-candlepower (10000 lumen) MAZDA C lamps in ornamental lantern fixtures spaced 90 feet apart and located opposite each other at a mounting height of 15 feet. Two other streets, Superior and St. Clair Avenues on the other hand are very inadequately lighted between these limits. Only one 400-candlepower (4000 lumen) lamp for about every 300 feet of street is provided. A survey from the police records of the automobile fatalities in Cleveland for the year 1923 shows that on Euclid and Woodland Avenues only 2 night fatalities occurred,—one on each street. While on Superior Avenue there were 8 and on St. Clair Avenue, 7. This is in spite of the fact that during the daytime when, of course, there is no difference in lighting conditions, the number of fatalities on Euclid and Woodland were practically the same as on Superior and St. Clair, in fact, slightly more.

Who's to Blame?

It seems logical that a community must hold itself directly responsible for night accidents such as the one described in the following extract from a recent newspaper:

"STRUCK BY FOUR CARS, FINALLY PICKED UP DEAD"

"An unidentified man between 65 and 68 was struck by the fender of an automobile as he attempted to cross.............. Ave. N. E. at E. 33rd street. The driver pulled up to the curb to give aid. Before he reached the victim, three automobiles had passed over the figure lying on the pavement, apparently without seeing it."

It is not an uncommon experience, particularly on a dark, rainy night, for an automobile driver on a heavy-traffic street to discover a pedestrian within a few inches of his automobile fender—a slight change in the direction of the car would have caused an accident. All too frequently, *the pedestrian fails to realize the danger because he thinks that he is as clearly visible to the driver as the approaching car is to him.* Bright automobile headlamps against a dark background cannot be mistaken, but such is not the case with dark clothing against an equally dark background.

Types of Common Accidents Which May Be Prevented By Adequate Street Lighting

Types of common accidents which may be averted by good street lighting may be summarized briefly as follows:

A. Driver runs into obstruction or break in pavements. Street lighting especially on the thoroughfares, should reveal all small breaks in the pavement or obstructions on the street. These requirements necessitate a fairly uniform distribution of brightness on the street surface in which the obstructions and dangerous faults are seen either as shadows or breaks in the sheen in the case of streets with a polished surface or in the case of all pavements which are wet.

B. Driver strikes pedestrian stepping into street or waiting in street for street car.

The spacing of lamps should be close enough so that there will be no dark areas between units. On wide streets satisfactory results can be obtained only by lamps located on both sides of the street.

C. Driver collides with another machine or street car on entering thoroughfare from side street.

On account of the additional traffic the lighting requirements of thoroughfares are more rigid than those of the side streets leading into the thorough-

fares. The thoroughfare system should be so designed that the crossings are especially well illuminated by a judicious placement of lamps. This increased amount of illumination in a well designed system at once indicates to the driver that he is nearing a main artery of travel and warns him to be cautious.

D. Driver coming into thoroughfare from side street strikes pedestrian crossing side street. The likelihood of this type of accident is avoided by the same treatment of the lighting system as outlined in C. A high-powered lamp at the head of the street not only warns the driver to proceed cautiously, but furnishes a bright spot of light underneath the lamp against which a pedestrian is seen in silhouette.

E. Driver over-runs at dead-end or at turns.

A lamp of adequate power placed at the head of the dead-end street or on the outside of the turn illuminates the curb and surroundings. At particularly dangerous spots where the traffic is heavy, warning beacons may be used to advantage.

On winding park boulevards or on streets which have a number of curves and sharp turns an automobile driver is more likely to become confused by a staggered system as this arrangement of units does not clearly indicate the direction of the road. With the units on one side of the street or in the case of wide streets, with units on both sides opposite each other, the direction which the road takes is revealed even though the road surface cannot be seen.

Crime

Not only does street lighting tend toward the reduction of the traffic accident hazard, but it also has a very important bearing in the reduction of crime. The recognized feeling of increased safety amid well lighted surroundings rests upon a more substantial foundation than simply an inherited dread of the danger of darkness; for the criminal makes his approach without warning when there are dark shadowy spaces, and his escape is made many times more sure when there are conveniently dark passageways and alleys in which detection is difficult.

A survey made in Cleveland by Mr. Ward Harrison, indicates that 90% of the street crimes take place after dark, and that in Cleveland the White Way installation was responsible for a 41% decrease in nocturnal crimes in that district.

Commercial Advantages

Street lighting is one of the most economical and effective mediums for advertising the progress and prosperity of the smaller cities. The city which does not have a white way system is branded by the traveling public as lagging behind in civic betterment, and what applies to the smaller cities applies also to specific streets in the larger cities.

The experience of dozens of communities has shown that proper street illumination is of advantage in providing favorable conditions for prosperity and progress in several ways. For one thing, there is a distinct gain in business efficiency from the extension of the hours of operation for which the safe and comfortable use of streets at night is a requisite. Further light exercises a definite attraction for all people. How the illumination of a white way street-lighting system changes a street, which previously was practically deserted after sunset, into a scene of activity and life throughout the evening hours is a familiar story. In specific instances where only one of two commercial streets was equipped with new lighting, the well lighted street has gained in the ratio of two to one or even three to one in evening traffic as compared with the poorly lighted street. The effect upon property values of such a concentration of business is obvious to all familiar with the way trade follows the crowd. Without considering the business interests of the merchants, well lighted business streets represent a real advantage to that very considerable number of the population engaged in work throughout the day and who, therefore, must do their shopping during the evening hours.

Contributes to Comfort and Convenience

While the fundamental or elementary service performed by street lighting is

that of accident and crime prevention, it has an equally important part in contributing to the comfort and convenience of the community. A satisfactory street-lighting system not only makes possible the traversing of sidewalks and streets, but effectively reveals minor inequalities in sidewalks and paving surfaces and makes walking both safe and pleasant. Even in less frequented locations a printed or written address is readable without striking a match. Street signs are well enough lighted to be easily made out without the necessity of stopping to decipher them. House numbers are visible at a reasonable distance. Passing friends may be recognized on the streets in any part of the city. In the more congested areas a satisfactory level of illumination makes it possible to read newspapers or other matter while waiting anywhere on the sidewalk. The goal of a street-lighting plan, which is reasonably attainable without an undue expenditure, should be that the normal daylight activities on streets may proceed at night practically without delay or increased difficulty.

Chicago Residence Street Lighting

By J. C. Hail*

Presented December 22, 1924

This paper gives a description of the latest installation of street lights in residence districts in Chicago. Here the influence of shade trees dictates the use of properly shielded lamps at comparatively low mounting heights. New economies were introduced in the methods of laying cable in parkways, building foundations and assembling the units for use. This work was largely done by the city under day labor.—Editor.

EXTENSIONS described in this article, are recent ones, consisting of 6,548 two hundred and fifty-candlepower lamps, generally in the outlying residential sections. The construction work for this installation as a whole was started on July 29, 1924, and today we have 1264 of these units in service. We will have another thousand in service by the first of the year and the remainder probably within the next sixty days from January 1st, weather conditions permitting. The installation has been financed from the $2,000,000 bond issue street lighting fund.

At the present time and not including the extensions, Chicago's municipal street lighting system includes 28,031 600-candlepower units, of which 4,223 are supplied from underground circuits, and 23,808 are supplied from aerial circuits. The spacing is generally 220 feet to 330 feet, depending on the district and city block formation and the light source is from 22 to 25 feet above the street surface. Another class of lighting consists of 28,207 100-candlepower units, supplied from underground circuits. They are spaced 75 feet per linear foot of street, in a staggered relation, and the distance of the light source above the street surface varies from nine feet six inches in one type to ten feet six inches in another type. Including all types, 56,730 street lights comprise the Chicago municipal system which is supplied from twelve substations, and is probably the largest municipally operated system anywhere. The number of employees devoted strictly to street lighting is 450; the present value of the system is about seven million dollars; and the yearly expenditure for street lighting operation and maintenance in 1923 was $1,273,784.

Any extension to a system of this magnitude involves the careful consideration of many economic factors. Such extensions must be capable of being absorbed into the existing system with reference to substation equipment, globes, cables, transformers and the like, and the manner and labor of maintenance must fit into the organization available. The design of new units added in the midst of a number of existing units of a previous type should be such that the

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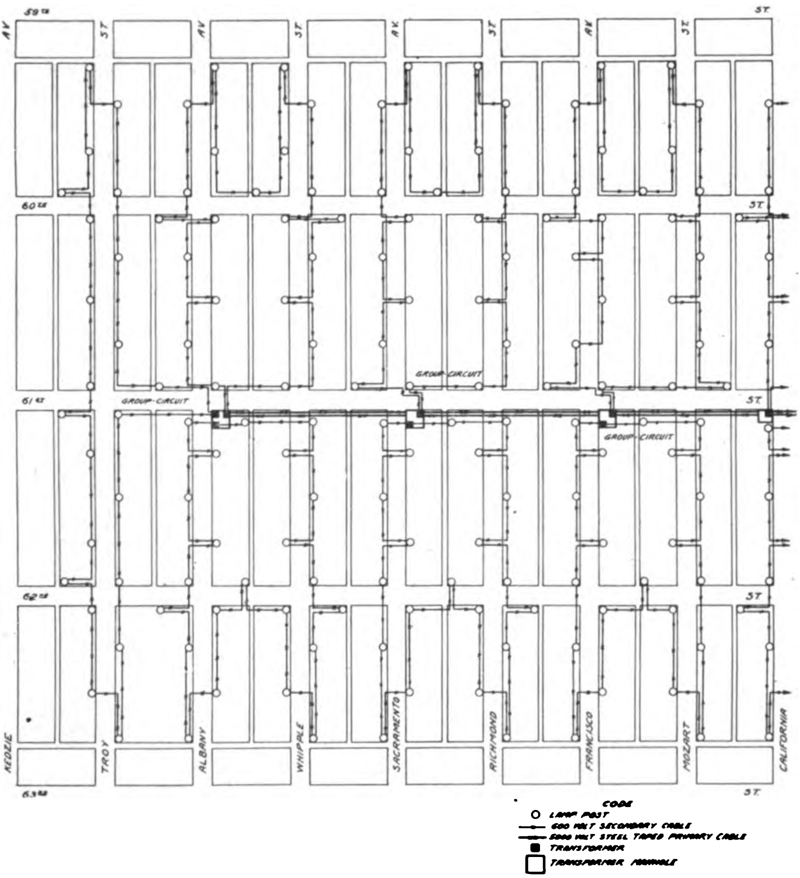

FIG. 1. PLAN OF A TYPICAL RESIDENCE SECTION OF CHICAGO SHOWING LOCATION OF STREET LIGHTS.

same crew that is operating that general section can take care of the new system without any greatly added expense, or different labor methods.

All the detail equipment on the new system, insofar as possible, should be standardized with the existing system or, if a new type is adopted, it should be capable of being adapted to the old system from time to time as finances permit to improve it and result in the reduction of operating expenses. Any construction that is adopted should be as simple as possible, so that the minimum amount of labor can be employed, to reduce the construction cost of such a system. The new system should represent the latest developments in the art and provide illumination sufficient for the purpose, and, if possible, show a saving in construction and cost of maintenance and operation over previously existing systems. All of these things are considerations that should be given careful thought in considering any form of extensions.

Chicago for a number of years has not had a definite program of street lighting extension. At least thirty square miles of residential territory, prior to the work of this extension, were without light, or very infrequently lighted by gas or gasoline lamps. All the forces of study and investigation were directed to providing the best residential lighting system for these territories, bearing in mind the financial investment, the economy of operation, and the illumination required. The Commissioner of Gas & Electricity, and his engineers toured cities in the

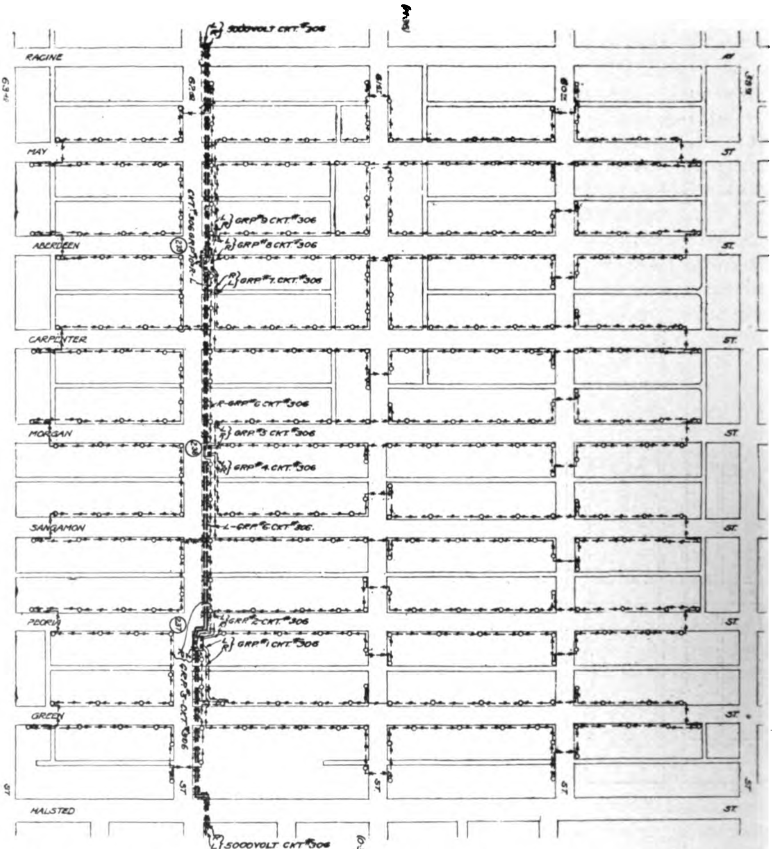

FIG. 2. DISTRIBUTION SYSTEM FORMERLY USED IN LIGHTING RESIDENCE STREETS IN CHICAGO.

East, including New York, Cleveland and Philadelphia. They spent considerable time at Nela Park at Cleveland, and also visited Washington, Baltimore, Milwaukee, St. Paul and Minneapolis and other cities, in an effort to collect all the possible available information on the types of lamps, globes, posts, the investment, and costs of operation and maintenance, to determine the best type of residential lighting installation.

After gathering all of this information, experimental installations were made on existing circuits. We had various types, several different forms of posts, concrete posts of two different kinds of manufacture, the Union Metal standard post, the cast iron post, and lanterns from the various companies, lanterns with refractors and without refractors, and with reflectors. We made tests on the various installations, figured the cost of operation, estimated the construction cost, gathered all these figures for the purpose of considering what would be the system best suited for the city to adopt in these extensions.

The geography of the City of Chicago in the outlying sections—I mean by that the block formation—gives us certain fundamental considerations that we must recognize in planning any residential lighting system. The ordinary residential block in the outlying sections of the city is 660 feet long. The motor traffic in the City of Chicago demands a very high degree of illumination at the street corners. For that reason we felt it was fundamental that two lights should be placed at the street corners. We felt

next that since the City of Chicago is laid out on the alley system that the next important consideration was to light the entrance to the alleys. Then to complete the layout of the system, to place one additional light in the center of the block. We feel that by this kind of layout, a very highly illuminated street intersection is obtained which is desirable for motor traffic and protection to pedestrians and that in placing a light at the alley intersection we light the entrance to the alley and provide a public safety service. With reference to the illumination in the middle of the block, this spacing is slightly more than the spacing from the alley to the corner, but we feel that if there is any compromise of illumination, it can be made in this manner.

Figure 1 shows a typical layout of a section of the City of Chicago where our installations are being made. A section such as this will take approximately 175 lights and is one-quarter of a square mile in area. The general system of distribution is to receive electrical energy from the municipal substations, supplied by the Sanitary District of Chicago at 12,000 volts. Transformation is made in the substation to 5,050 volts, the transformation being from a 12,000-volt delta, three-phase, three-wire system to 5,050 volts, three phase, four wire system. The single-phase circuits are taken outside the station for the most part in eight conductor cables, eight wires being contained in a lead encased cable and carried through conduit lines to some center of distribution. From such center of distribution probably two wires will be used of that eight conductor cable, and carried up to the point at which the primary circuit of the distribution circuit is buried in the parkway. This circuit operates at 5,050 volts and consists of a steel taped cable, forming the central stem of distribution. The cable passes through manholes located in the parkway and connects to transformers in these manholes. The electrical characteristic of this primary circuit is 6.6 amperes constant current.

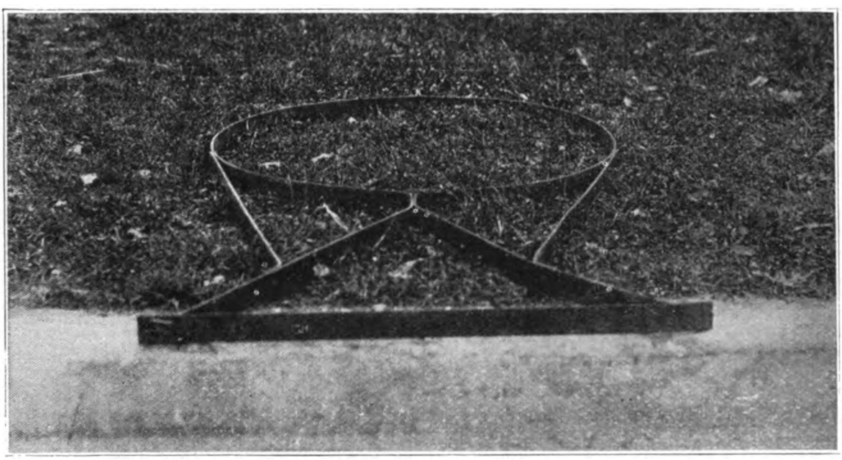

FIG. 3. TEMPLET USED IN DIGGING HOLES FOR FOUNDATIONS IN PARKWAYS.

The secondary circuit from the transformer is also 6.6 amperes constant current, has a capacity of 4,200 watts, and will supply 25 250-candlepower lamps. In general the cabling is on one side of the street, and the voltage available on the secondary side of these transformers is 636 volts. Each transformer is practically two transformers in one, the middle connection being grounded so as to give a voltage to ground of half of 636, or 318 volts, so the maximum potential on the circuit is 318 volts. In crossing streets the cable is run through iron pipes pushed underneath the pavement by means of a jack, saving the expense of tearing up the pavement.

This "series-group" system has been developed to a large extent in Chicago. I want to call attention to the fact that

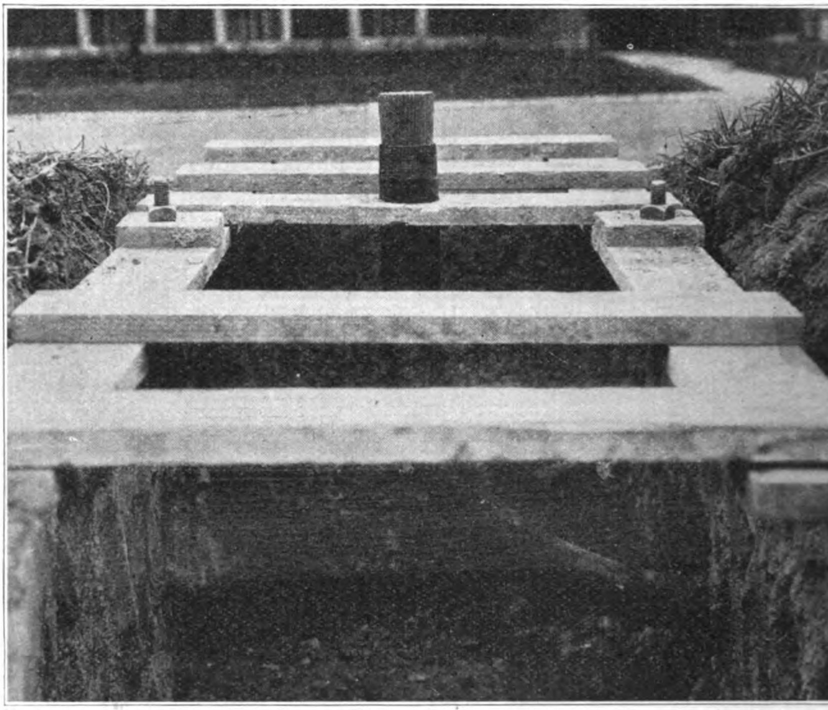

FIG. 4. CONDUIT HELD IN WOODEN FORM WHILE CONCRETE IS POURED.

there are five lights to the block, and the cabling is generally in the parkway on one side of the street, making it unnecessary to tear up the parkway on the opposite side of the street.

Figure 2, by way of comparison, is the system now used on the older installation of approximately 20,000 lamps, in which the general layout is nine to the block, two lights on the corner, and one light for each 75 lineal feet of street, making in general nine to the block; and on cross streets, three to the block, each of these lamps being of 100 candlepower. Therefore, with nine to the block, we have 900 candlepower to the block. We have on the side streets three units of 100 candlepower each, or 300 candlepower. So, if we take the units of one long block and one short block of cross street, we have 12 units. Contrasted with this, in the new installation there are five 250-candlepower lamps, or 1250 candlepower, in the long block and one unit of 250 candlepower in the short block, permitting the use of half the number of units and giving 1500 candlepower.

Notice further that the 250-candlepower system, five to the block, in most cases obviates the use of cable down each side of the street, diminishes the number of posts by one-half and makes a very large saving in the amount of cable.

I have tried to compare the two systems, showing the improvement of the 250-candlepower over the 100-candlepower. As far as the illumination is concerned, the illumination provided in the center of the street at the present time is given by 200 candlepower with the old system, while with the new system 500 candlepower is provided. The illumination, from studies that have been made at Nela Park is estimated to be four to five times greater with the 250-candlepower lamps than with the 100-candlepower lamps, at the street intersections and will greatly increase the illumination at alleys and give generally a much more pleasing effect.

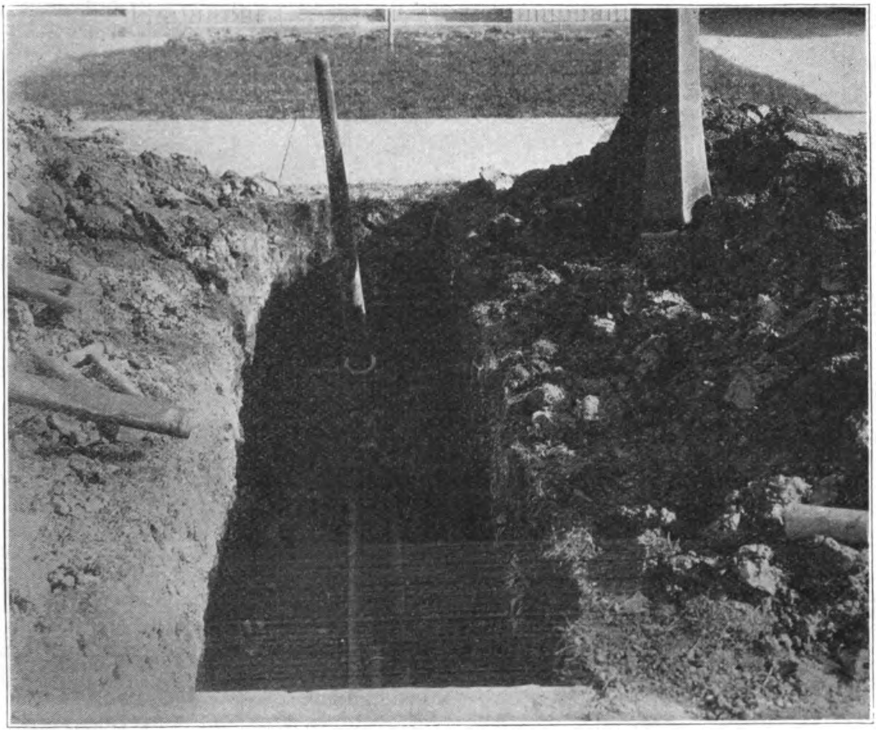

FIG. 5. PUSHING THE PIPE UNDER THE STREET WITH A JACK SAVES TEARING UP THE PAVEMENT.

Several attempts were made to secure bids from contractors to install the work and it was finally decided that the city would proceed by day labor, with its own forces, to install approximately 1500 lights. In the meanwhile bids were advertised for again, in an effort to secure more favorable prices, and a contract was awarded to install 2192 lights. In view of the delays of advertising and letting contracts and the fact that construction weather was fast slipping away from us, and since we were already engaged at top speed doing this class of work and were equipped with plant and trucking and other materials and organization, it was decided that the city would proceed by day labor to install the remainder of the 6548 lights. So the construction work is being carried on practically one-third by contract and the other two-thirds by day labor by the Department's own construction forces.

The following paragraphs will show some of the construction details of the work. Figure 3 is an iron marker. In starting construction work it was found most advisable to have an iron marker constructed of this type and placed adjacent to the curb, so as to insure the same position of every hole that is dug for a lamp post foundation. A lineman preceeds the regular digging gang and digs a few shovelfuls in line with the inner ring and the laborers later come along and finish the thing up.

Figure 4 shows the use of a template to hold the pipe bend through which the cables run, which is held in position by this wooden form. Three bolts are set in the template, to which the post itself is later attached.

We started this construction work on July 29. The matter of delivery of posts was a serious question whether they could be manufactured quickly enough to meet our requirements. We were forced to adopt a system whereby the foundation was separate from the posts and build all of these foundations while the weather

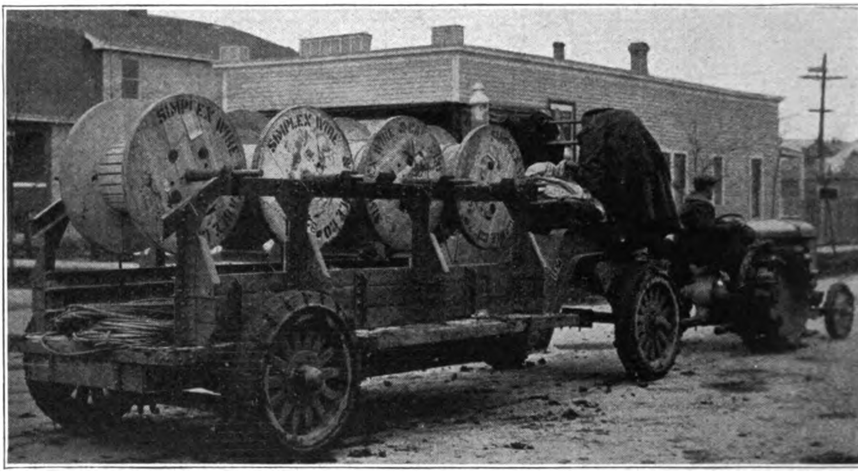

FIG. 6. CABLE REELS WERE HANDLED ON A SPECIAL TRAILER PULLED BY A TRACTOR.

was good and install the posts later by attachment to the foundations, so there would be no delay in the work.

The general method of installing the foundations was to choose a central location, probably of some 150 or 200 posts, and place a concrete mixer there. In order to minimize the amount of dirt that would accumulate in front of the houses due to the mixing of concrete and eliminate the wheelbarrow and to secure the maximum possible speed, the mixture of concrete was poured into concrete carriers. These are built on a Ford one-ton truck chassis, with a dump body and an apron on the rear so designed as to spill the concrete exactly into the hole without any adjustment, measuring or other maneuvering being necessary. By this method of construction we also had absolute control over all the work of installing post foundations. It was absolutely necessary for a truck to come to the mixer for the concrete and we could depend upon his return as an index as to whether or not the holes were being dug.

We were able to install 150 foundations per day.

Figure 5 shows a pipe-pushing jack. There is a trench dug immediately to one side of the street in the parkway, sufficient to admit a pipe pushing jack, and on the other side of the street a smaller hole, so that the end of the pipe can be found, plugged and marked. This jack is placed in the trench and an eight-foot length of pipe, is inserted in it. There is a ratchet bed, a lever, and a dog and the backward and forward motion advances the pipe and pushes it through

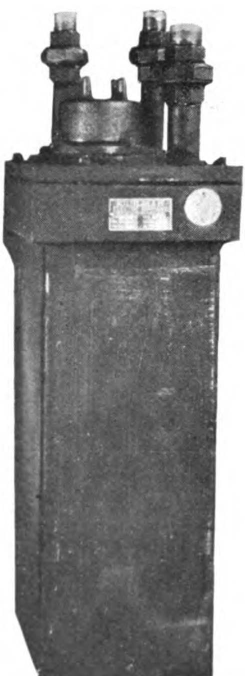

FIG. 7. CONSTANT-CURRENT TRANSFORMER READY TO BE INSTALLED IN MANHOLE.

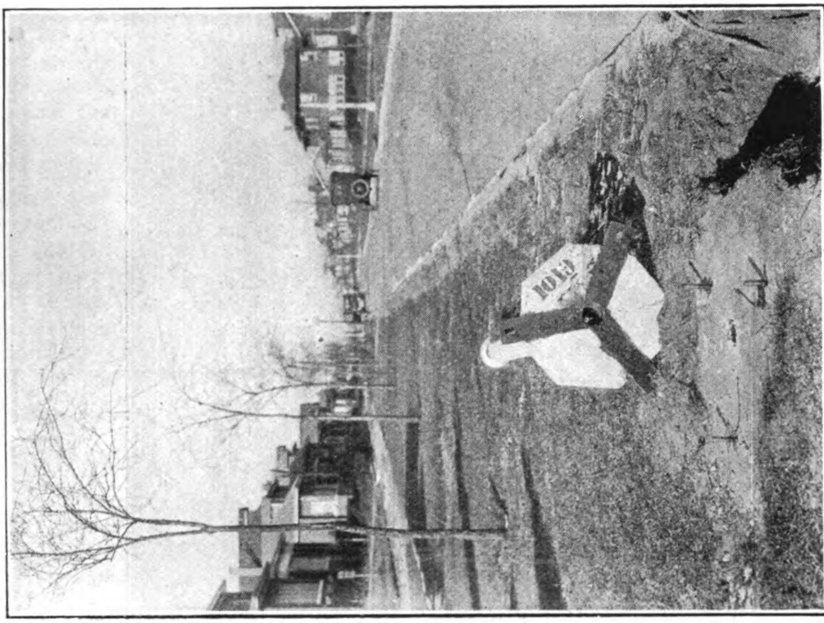

FIG. 8. FOUNDATION READY TO RECEIVE CONCRETE POST WHICH HAS AN IRON SPIDER AS SHOWN.

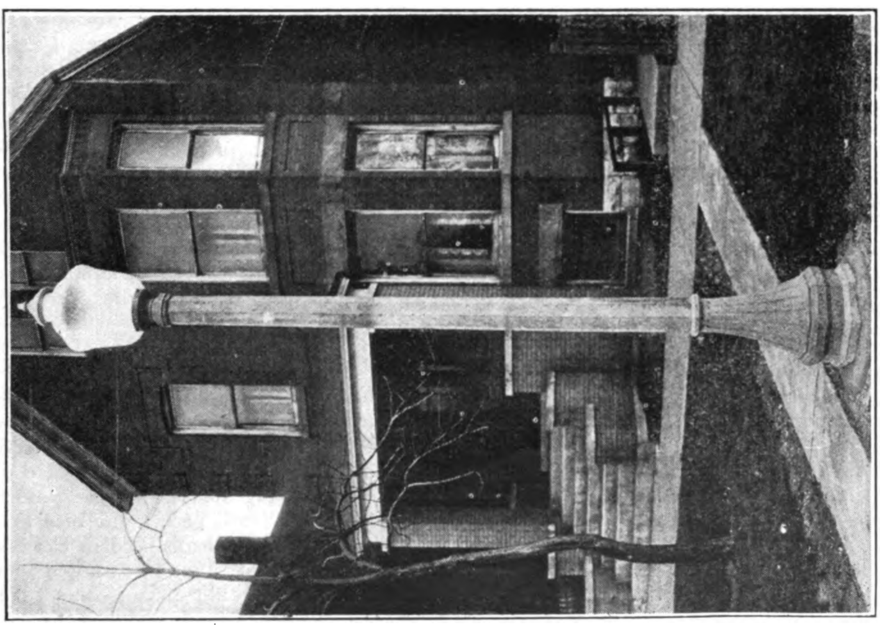

FIG. 9. COMPLETED LIGHTING STANDARD.

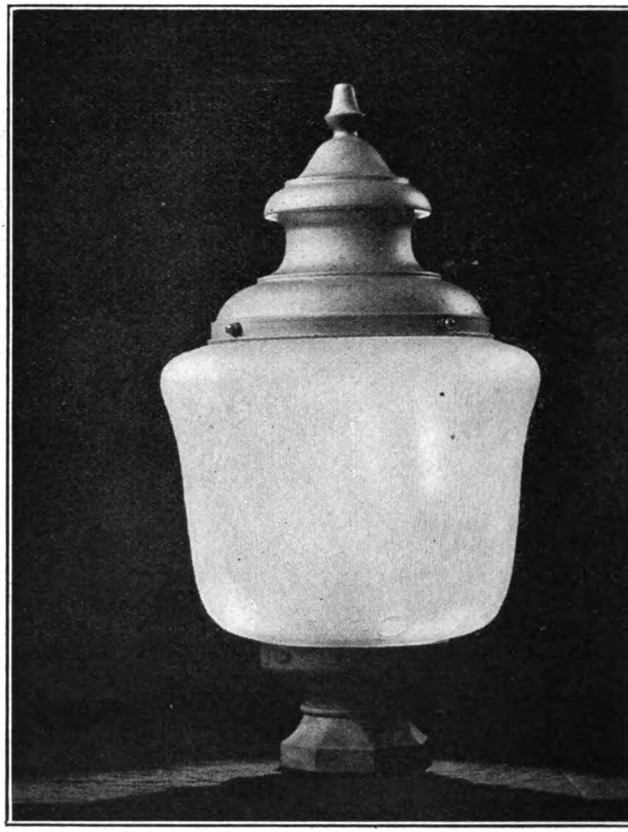

FIG. 10. THE LIGHTING UNIT READY FOR MOUNTING ON TOP OF THE POST.

the earth. By this method we were able to save the tearing up of pavements and driveways and eliminate the paving charges.

The 600-volt parkway cable from the secondary of the transformer is installed in a trench approximately eight inches wide, sometimes wider, if necessary, dug adjacent to the curb to a depth of 24 inches. The parkway cable is laid in the trench without any further protection and the earth is put over it. The 600-volt parkway cable, No. 8 B. & S. Gauge solid copper, single conductor with a 3/64 inch thick wall of 30% para rubber insulation, a 3/64 inch wall lead covering and an impregnated jute covering over it to save the lead from abrasion and also to protect the cable in handling.

Figure 6 shows a trailer pulled by a Fordson Tractor, with the cable rigging installed on the trailer to carry four cable reels. Each cable reel contains approximately 1800 feet of 600-volt cable and with four reels on the rigging, the trailer carried 7200 feet of cable. This can be carried forward and the cable installed in the trench. We were able with this outfit to attain a speed ranging from 25,000 to 27,000 feet of cable per day completely installed.

Figure 7 shows the type of transformer installed in the manholes to furnish this type of lighting. The general construction of this transformer must be absolutely waterproof. It must also have disconnection features, so that in case of trouble, by simply unscrewing the unions the arrangement will permit the insertion of a duplicate transformer and in case of non-availability of another transformer immediately, it would permit the 5,000 volt line to be closed and permit the rest of the circuit to operate. These

transformers are 4200 watts in capacity and are provided with a secondary short circuiting device. In case of an open circuit on the secondary of this transformer the film is punctured in a plug receptacle that is held beneath the cap and the secondary winding is short-circuited, protecting the transformer.

Figure 8 shows the concrete post before erection. The construction of this post includes a malleable iron spider with a hole in the center, and the center of the spider is threaded to receive a two inch pipe which extends entirely through the column of the post. The pipe is threaded on the top to receive the post heads. The post is reinforced and is 12 feet high. Figure 9 shows the unit completely installed with the head.

Figure 10 shows the post head fixture which is especially adapted for our purpose. It differs from most other forms of this unit, in that it provides a larger glass area at the lower part, thus permitting a greater amount of light to be dispersed in a downward direction to illuminate the base of the post. The globe unit is supported in an aluminum casting which is threaded on the inside so as to permit it to be screwed directly on the two-inch iron pipe that forms the central part of the post. The top portion is an aluminum spinning.

Highway Lighting

By R. K. Malcolmson*

Presented December 22, 1924

Lighting the more important highways is a subject that presents opportunities for economic studies that may show astonishing results. The question hinges largely on methods of financing and distribution of expense. In this paper Mr. Malcolmson outlines some of the general practices and the difficulties encountered.—Editor.

MOST of us have foresight enough to see that a new type of street lighting is rapidly becoming necessary and that is highway lighting, especially on the highways immediately outside of the larger cities, and connecting suburban towns.

Traffic out of large cities to adjoining suburban towns, and also all traffic between adjacent large cities is so congesting the highways in the daytime that the only feasible solution to relieve traffic congestion is to get the bulk of that freight and cartage traffic moved during the night. Take for instance the truck deliveries from the large department stores to the suburban towns and the intercity truck deliveries—if we can concentrate the movement of that traffic in the period between midnight and dawn, when the roads and highways are not so much in use, it will have a tendency to relieve congestion in the daytime.

A survey made in New York showed that traffic delays in New York City caused the living expenses to be about a third higher than in the surrounding towns,—that traffic delay, of course, was accounted for in the added cost of delivery and other economic expenses.

Only last week the Chicago Tribune carried an article about one of the large department stores in New York considering the delivery of all goods within the city by horse-drawn vehicles and doing away with motor trucks, because the motor truck standing idle so long in traffic delays made it a poor investment from the point of view of the retail store.

Something must be done to relieve traffic congestion. One plan is to increase all of our highways to a width of 24 feet and even wider, so as to relieve the city streets as much as possible of any unnecessary truck deliveries during the day. Night traffic is becoming of especial importance on the highways on account of the rapid growth of the suburban communities. On the principal highways leading out from Chicago on week ends due to extreme traffic congestion, one can probably walk along them as fast as he can ride over them.

The first lighting plan for highways

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should include all highways leading directly out of Chicago, to the suburban towns, and then others as the comparison of expenses of highway lighting and the resultant benefits have shown the lighting to be worthy of additional appropriation. State highway lighting should be extended throughout the state on all of the highways ,and finally throughout the country, so that all of the principal roads will be lighted. Of course, we cannot hope for that at once.

Distribution Problems

This problem of highway lighting means that we have to give some attention to electric distribution for lighting units along the highways. It is different from the city streets, in that the ordinary residence lighting is mainly a protective lighting; then of course we also have our white way ornamental post lighting, which is advertising lighting as well as protective lighting, but highway lighting is an economic necessity as well as ordinary protective lighting for traffic. Illumination on the highways should be uniform, and of high enough intensity to provide a clear vision for the driver at least 100 feet in front of the vehicle. Economy of installation cost will determine how close together the units can be placed. The ideal placing or spacing of the units would be approximately ten times the mounting height, but this sometimes might be too expensive, so that the best spacing will be one that will be within the financial bounds of the lighting appropriation available.

The state highways are well protected by laws regarding the distance of pole lines from the center of the highway. I think the average distance from the edge of the highway to any pole or sign that can be constructed along the state highway is about nine feet. The chief trouble and inconvenience on highways at night, is the glare resulting from opposing automobile headlights. If any adequate provision is to be made for proper highway lighting, the light must be placed high enough so that it will be out of the normal range of vision and to provide even, uniform illumination so that there will be no blinding or spotty lighting effect.

The ideal spacing is about ten times the mounting height of the lighting unit. The lighting unit should be approximately thirty feet from the ground, so that a spacing of ten times the mounting height would give a distance of about 300 feet between successive units. If a pole line for electric suburban and rural service is already established along a highway. the units will have to be spaced according to the spacing of the pole line. Pole lines on most of the Chicago highways have an average spacing of 125 feet. If a light is placed at every third pole, we would have an average spacing of 375 feet. That might not be ten times the mounting height, but it might be the closest approximation that can be obtained. In Indiana on the Lincoln Highway an ideal lighting installation was made with the lighting units installed on concrete poles, and of course there the spacing could be determined to suit the requirements.

Investment Necessary

Unfortunately, pole lines for installing highway lighting are not always available. Away from the larger cities, the rural line extensions of the public servicing companies to outlying towns are used. That means that the lights, if they are to be placed on the existing pole lines, ordinarily will be on pole lines that are too low to permit a thirty foot mounting height. As practically all of the pole lines along state highways carry high tension service, it is not a very good practice to try to locate a lighting unit above the high tension line, so that, although from an ideal point of view a 35-foot mounting height should be used. sometimes it is rather impractical on account of the presence of other wires or other service on the pole line.

That brings up a question as to whether highway lighting should be kept distinct and apart from the distribution pole line of the public servicing companies.

This presents the question of investment needed for the highway lighting including the additional poles, the distribution wires and the fixtures. In the Chicago territory there are three possible ways of having highway lighting financed,

either directly financed by the state, by the township, or the villages through which the highway passes. It is a pretty hard thing to say who should finance highway lighting. It is a thing that will have to be worked out and worked out very soon on account of the increasing daytime congestion on city streets, the added night traffic, and the especially heavy night traffic that should be on the highways if they were properly lighted.

Requirements

A successful highway lighting unit should have the following properties: It should be able to use a fairly small lamp, such as 250 candlepower, or possibly 400 candlepower and yet throw a high intensity of illumination on the roadway. That means that no light can be wasted in the fields, no light can be wasted upwards and no light can be wasted either on the side of the road or directly underneath the unit. The light source should be removed from the line of vision, so there will be no blinding effect, and the unit should provide uniform illumination over the entire highway. Of course this will be determined largely by the spacing of the units. Practically every one of the highway units now on the market does these things either by the use of glass refractors or by refractors and reflectors combined, and in the case of one unit, by the use of a highly polished parabolic reflector.

A discussion of the design of lighting units could require a whole evening so I will not enter into that now. What I want to bring up here is the feasibility of highway lighting, and its importance; especially now, with the congested conditions of our streets and highways.

Another important factor in a highway lighting unit is the maintenance, the lamp renewals and the cleaning of the unit. A unit placed 35 feet in the air is sometimes rather hard to reach to replace lamps, and from the point of view of an operating company I think that is sometimes under-estimated by some advocates of highway lighting. To have a man climb up a pole to a height of 35 feet and unscrew a lamp, clean it and screw it back in again, clean the reflectors, etc., takes a lot of time. The unit should be designed so as to make that work as easy as possible.

Adds Small Cost

The necessary expenditures for highway lighting are very small compared to the cost of an 18-foot concrete pavement. According to the records of the highway department, I believe the concrete pavement in Cook County costs between $35,000 and $40,000 a mile, that is, an 18-foot pavement. For $2,500 additional cost per mile a very good system of highway lighting could be installed. That would make the highway useful 24 hours of the day. That is less than ten per cent of the cost of building the highway, and it certainly should be worthy and should be valuable enough to be justified on account of preventing accidents, eliminating the glare from auto headlights and adding to the comfort of the night driver. It would decrease the running time of trucks and pleasure cars between the larger cities and the suburban cities. It would increase real estate values by tending to bring the growth of the city along those lighted highways. And from the operating standpoint of the utility company, it would bring electricity to rural communities, to farmers and to smaller settlements that wouldn't have this service if there hadn't been a pole line. Probably any highway lighting that is installed in the next few years will be in connection with the distribution lines of a utility company, on account of the expense.

Granting that highway lighting has passed the experimental stage, because in the East it has been worked out very successfully, some means must be provided to finance it and make it an established fact. Some steps must be taken, either to get a bill through the legislature to make an equitable division of expenditures among the different parts of the state—the state might bear a part of the expense or the township or the village, but each one of these political divisions must make up its share of the expense.

Present Chicago Paving Practice

By JOHN B. HITTELL*, M. W. S. E.

Presented, February 24, 1925

The two papers presented here give a good picture of the complicated situation confronting municipal engineers since the advent of automobile and heavy truck traffic on our city streets. This paper gives the more general problems including engineering and legal and describes the types of pavement that are now found to be satisfactory. The pavements of a generation ago would not suffice for present-day traffic. The second paper goes into the economics of renewing pavements.—Editor.

Paving Design

AMONG the general factors controlling paving design for the City of Chicago are: traffic conditions, climatic conditions, topography, soil, and available materials.

Since the perfection of the internal combustion engine, which made the automobile the popular vehicle for pleasure and the truck for commercial purposes, paving engineers have been obliged to meet traffic conditions essentially different from those existant a few years ago. The steel-tire slow-moving traffic is replaced by one of great intensity, a high rate of speed and increased loads, but with the modifying effect of a non-metallic and resilient tire, the latter at times equipped with chains. These conditions have resulted in eliminating the water bound macadam pavement and are demanding pavements with stronger foundations of the so-called rigid type, and more resistant surfaces in bituminous types, wider roadways, and concurrently, regulation of traffic under police authority of the city.

License records of the City Clerk of the City of Chicago for the years 1915 to 1924 inclusive, show the number of passenger automobiles, motor trucks and horse-drawn vehicles including motorcycles, bicycles, and sundry others. In these ten years, the number of horse-drawn vehicles dropped from 52,500 to 22,500 or over fifty (50%) percent, while the motor trucks increased from 7,500 to almost 45,000, an increase of five hundred (500%) percent. The passenger automobiles have increased in this period from 32,000 to 260,000 or over seven hundred (700%) percent. The number of horse-drawn vehicles shows an almost uniform rate of decline and the motor truck ar almost uniform rate of increase per year. The number of licenses issued for passenger automobiles in 1918 was practically the same as for 1917, showing the effect of unsettled conditions due to the call to arms. The years 1919 and 1920 showed a uniform increase of almost twenty-five (25%) percent. From 1921 to 1924, inclusive, the rate of increase is almost uniform for each yearly period. If we take the motor trucks and passenger autos together, we will have a total of 305,000. This number of automobiles, if parked four abreast, with an average of twenty feet of roadway per car, would cover two hundred ninety (290) miles of pavement; or if moving at thirty miles per hour, assuming an operating space of forty feet per car, these 305,000 cars, four abreast, would require over nineteen hours to pass a given point.

Fig. 2 shows the range in temperature in Chicago from 1919 to 1924, inclusive, as given by the United States Weather Bureau. The upper line is formed by connecting the highest temperatures obtained in the several months, and the lower line, similarly connects the lowest temperatures. The heavy vertical lines show the maximum daily range occurring throughout the year. The highest temperatures reached throughout these six years are very close together, ranging as they do from 94° to 98°. The variations in the minimum temperature are somewhat larger, ranging from —1° to -16°. The maximum daily ranges are very close together, approximating about 36°. It is possible that there are larger ranges than this as these records are only from mid-night to mid-night. On February 8th, 1900, 25 years ago, the temperature fell from 62° to 10° in fifteen hours,

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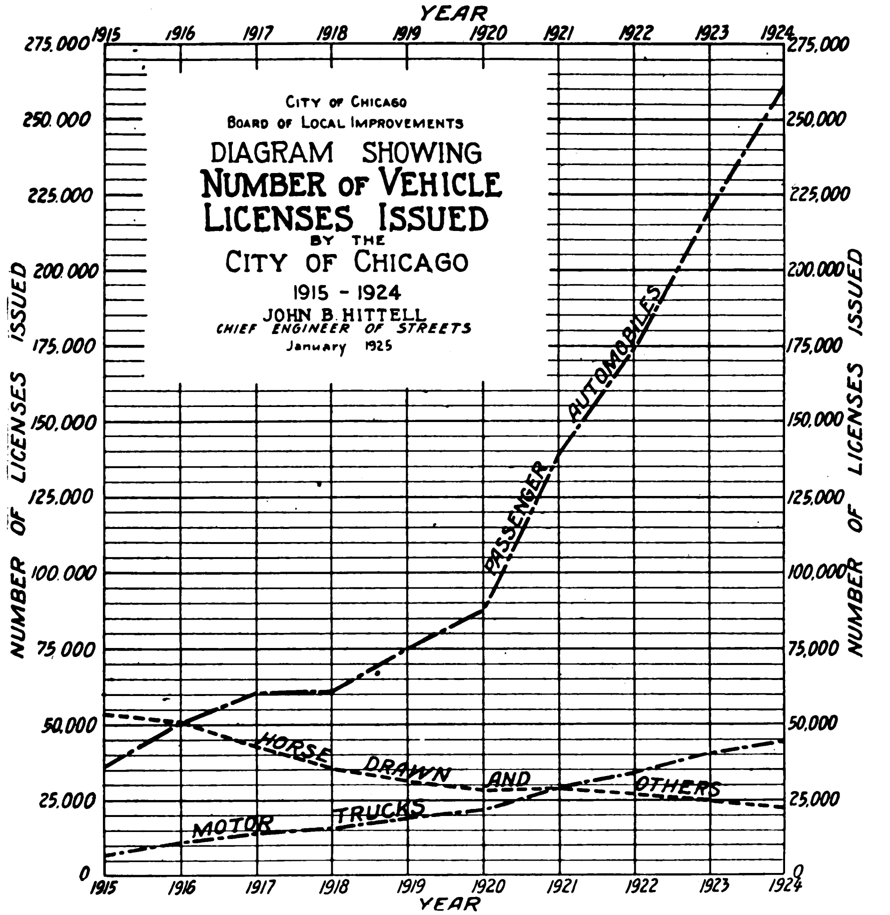

FIG. 1. THE TOTAL NUMBER OF VEHICLES ON OUR STREETS HAS MORE THAN TRIPLED IN TEN YEARS.

the greatest fall in history, with a wind that blew sixty-two miles an hour, a velocity exceeded but once. The maximum difference in temperature in this six-year period is 114°, but as these records are taken at a point of observation which is above that of street level, it is fair to presume that a range of 140° Fahrenheit is not an unusual condition for a pavement of the City of Chicago to endure, especially if the surface is of the type or color that absorbs heat rays. Since concrete which is generally the foundation for an asphalt pavement has a coefficient of expansion about the same as steel, the contraction may roughly approximate one inch to a hundred feet.

Aside from the Beverly Hills and Normal Park territory, the Clark Street and Ridge Road ridges and a few other spots, the topography of Chicago is quite level. The established grade at State and Madison is 14.0 above datum; at Irving Park and Broadway, five miles north, 11.0; at Kedzie and Madison, four miles west, 19.0; at Crawford, one mile further west, 24.5; at 47th and State, five miles south, 16.5; rising to 19.0 at 63rd Street, dropping down to 9.0 at 71st Street and reaching 8.0 at 87th Street, ten miles south of Madison. These small differences in elevation necessitate the draining of the pavements, by elevating the gutters at the summits, and depressing them at the catchbasin inlets. It is a rare case where drainage is obtained in our city pave-

ments through a sufficient gradient of the top of the curb. This condition results in the need of constructing more catch-basin inlets than are necessary to take care of surface water based upon its volume, and has no small bearings on the ultimate cost of the work. Likewise it also causes the surface of the finished pavement to have a continuously changing cross-section. Hence it is difficult in construction to obtain a surface with a desirable minimum amount of irregularity as usually determined with a straight-edge.

The character of the earth foundation varies from the heterogeneous mixture of the debris from the fire, placed in that part of the city where the grades were raised about four feet after that event; with sand and gravel extending along the lake shore, changing into blue clay further west with the outcropping of rock in the neighborhood of 93rd and Stony Island and in the vicinity of Augusta and Western Avenue. In the loop district the preparation of the soil for a foundation is controlled to a great extent by the condition that the area cannot be long kept from use, and dependence is placed in general entirely upon rolling. When the soil is sandy, flooding is the most effective, and with clay, flooding and rolling combined.

Chicago is fortunately situated concerning road making materials, as it has within a radius of about three hundred miles granite and trap rock, sandstone, brick, creosoted wood blocks, and beyond these limits rock asphalt is not very much further away; while within its local freight district are cement, sand, limestone, gravel, slag, asphalt, tar, flux oils. From this it will be seen that its location makes it possible to lay the accepted highest types of pavements without an undue increase in costs due to freight charges on long hauls.

The engineers in charge of paving divisions have had, in the past, rather a free rein in the physical design of the pavements, and from this, the present plan has resulted, after trying out individual ideas. The main idea of the plan is the level street intersection, no step or practically no step from the sidewalk onto the pavement at the curb line, and the drainage of the surface water away from the street intersection toward the center of the blocks, eliminating the dangerous false gutters and humps in the pavement in the lines of travel.

To overcome the influence of the vibration of pavements occasioned by street car traffic, it is customary with asphalt and concrete types of pavements to lay additional rows of granite block lengthwise adjacent to the right of way paving of the street car company; and in some instances, this granite block pavement is separated by a header curbing of granite set on concrete in such a manner as to furnish a line of separation between this brow pavement and the adjacent roadway pavement with the view of localizing the effect of vibration to this brow pavement.

The general design of pavement cross-section has been of the crowned type. However, there are proceedings under way at the present time for paving certain streets with the upper surface concave and sloping down from the curbs to a gutter at the center of the roadway. This design is economical in the sewer adjustment work, and as lesser depth of curb can be used.

Conforming to the rulings of the courts it is mandatory that the ordinance for improvements under the Local Improvement Act should be so clear that one familiar with the type of construction could build the improvement from the conditions of that instrument. This, in effect, means that the ordinance combines a design and specifications. The writer has been advised by a consulting engineer and member of this Society who had occasion to make a study of the improvement acts in this and adjacent States that the decisions affecting those acts were in the ratio of ten in Illinois to one in any of the other States.

With the limited funds at the disposal of the Board of Local Improvements, in paving cases it has been the practice to avoid attaching any drawings to the ordinance, the preference being to attempt to describe in words all that is to be done. This description covers such minor details as elevations of gutters and crowns with reference to established curb grade, elevations of the outlet of the drain pipe from the catchbasins at its connection with the basin and sewer, and its direction; the location of expansion joints,

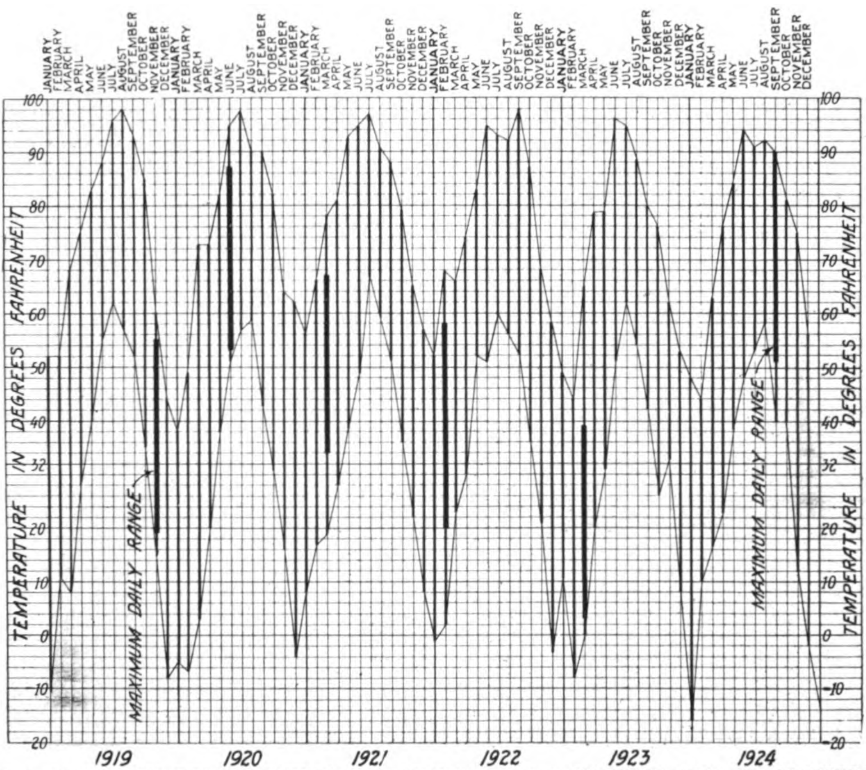

FIG. 2. MAXIMUM TEMPERATURE VARIATIONS OF 110 DEGREES ARE ENCOUNTERED.

catchbasin inlets, and the number of feet of pipe required to connect each one; and numerous other refinements of description which appear to engineers generally as absolutely unnecessary and too small to affect the estimate of cost.

Conversely, however, it must be considered that the Board of Local Improvements has great powers lodged with it to impose the costs of improvements upon owners of property and the latter are entitled to every protection in the application of the law. In the actual working of the law minor discrepancies or omissions are constantly being used by skillful attorneys to defeat the confirmation of the improvement or to force a reduction in the assessment against their client's property. Many think that the present law of Illinois needs complete revision or that amendments should be made to it which would permit a correction of minor defects by a supplemental action of the Board of Local Improvements and the City Council. The present condition results in a situation where a large percentage of the preliminary work done in the paving department goes for naught.

With the advent of the present administration it was thought advisable to rewrite the present specifications for asphalt, asphaltic concrete and asphaltic macadam; and also to prepare a specification for portland cement concrete pavements for streets.

Believing that a multiplicity of counsel of those by whom the work in the future would have to be executed was advisable, conferences were held late in the winter of 1923 among the representatives of the Board of Local Improvements, Bureau of Streets, asphalt producers, paving contractors, including plant and street foremen, testing laboratories, interested trades unions and the Portland Cement Association, and from these many conferences the present specifications resulted.

Sheet Asphalt Pavements

In order to meet the demand in a pavement for greater resistance to shov-

ing and rutting, the specifications as adopted provided for a lower bituminous content, namely, heavy traffic streets, 9.5 to 11.0, and light traffic streets from 10.0 to 11.5, instead of as formerly, without a division for traffic conditions, of *11.00 to 13.5; similarly and respectively the two-hundred mesh dust content of 16.0 to 20.0 and 12.5 to 16.0 instead of 11.5 to 15.0; a more rigid sand grading; penetration reduced from a range of between 30 and 100 to a range of between 25 and 70. A greater initial compression was provided by a change from the use of a small roller to that produced by means of a three-wheeled roller, weighing not less than ten tons, or a tandem roller weighing not less than fifteen tons. The thickness of the wearing course was also decreased from a commonly specified thickness of two inches to that of one and one-half inches, and the binder course was increased from a depth of one and one-half inches to two inches. The size of the stone in the binder course was also increased and the grading changed to correspond. The mixture in the concrete base for asphalt pavements as well as for other types was changed from 1-3-7 to a mix approximately 1-3-6, requiring 4.2 sacks of portland cement to each cubic yard of concrete in place. The upper surface of the concrete foundation was required to be roughened to provide a proper key for the asphaltic course instead of finished smooth.

Asphaltic Concrete

Changes in asphaltic concrete were practically along the lines followed in the case of sheet asphalt except that no binder was specified.

Asphaltic Macadam

In the asphaltic macadam pavement the foundations of ten (10) inches of water bound base are all now being laid in two courses, both of which are thoroughly bonded with limestone screenings. Graded slag is required instead of crusher run. Likewise the metal for wearing course was changed from limestone to trap rock or granite.

Concrete Pavements on Streets

A general design for concrete street pavements of a two-course type without reinforcement was outlined by the Board of Local Improvements and the specifications were based on this design. Later on in several instances, the Board has directed the laying of a one-course pavement six inches thick of the vibrolithic type.

The mix of the two course pavement is approximately 1-2-3½ (requiring 6.4 sack per cubic yard of finished concrete in place) for both layers, using either limestone screenings or torpedo sand with limestone or gravel in the base. For the wearing course torpedo sand and crushed granite or trap rock is specified. The thickness of the wearing course is two or three inches, and that of the base either six or seven inches—a complete pavement of 8 or 10 inches in depth—depending upon the traffic conditions. The wearing course is laid within forty-five minutes of the time that the base is laid.

Expansion joints ⅜ inch thick are placed across the concrete pavement at all street intersections in conformity with all curb lines produced; provided, that at the street intersections, where curb lines produced do not coincide and the interval between such curb lines produced is less than twenty feet, one joint only shall be placed. Transverse expansion joints are also placed at right angles to the center line of the roadway across the concrete pavement between intersecting streets, at intervals of thirty feet, or as near as may be but not exceeding thirty-one feet, measured along the center line of the roadway. A preformed joint filler is used.

Standard separation plates of number eighteen U. S. metal gauge having a corrugation along the center thereof, lapping two inches at their joints, and extending vertically from the base of the concrete pavement to within one-half inch of the top of the finished surface of the pavement, are placed along the center line of all roadways twenty to forty feet in width, which are without car tracks. On roadways above forty feet in width, additional lines of separation plates are used forming strips not less than ten feet or more than twenty feet in width. On roadways with car tracks, sixty feet in width or over, two joints are placed midway between the curb and tracks. A

* Special specifications were usually drawn for unusually heavy traffic streets.

building paper separation plate, weighing twelve pounds per one hundred square feet, is placed between the concrete slab and the gutter.

Finish

Finishing by rolling and belting is done from the sides and from bridges. The use of a long-handled wood float is permitted where necessary. The edges are tooled along the gutters and expansion joints. As mentioned before the surfaces of the pavements have a continual change in crown in order to secure surface drainage. This precludes the use of the customary finishing machine and so our standard of surface finish is not as exacting as on country highways. The allowable departure from a ten-foot straight edge is 3/8 of an inch. We may also be justified in this because the allowable speed limits in the city are less than in the country. In one instance we have decreased the crown at the summit with pleasing results in the appearance of the street. Our mistake has been in having too much crown in concrete pavements.

Curing is done by the use of wetted burlap and the application of calcium chloride to the extent of two pounds to the square yard; or of silicate of soda to the extent of one pound per square yard, with the provision that when the temperature is above 80° Fahrenheit, the silicate of soda may be reduced by the addition of 25% of water; or also at the discretion of the contractor, by covering the pavement with two inches of earth or wetted straw. Between July 1st and September 15th, the pavement is kept closed to traffic for 14 days, in other working periods 21 days. Woven wire fences are set the length of the day's run along the curb lines to protect the work from being marred by animals, human or otherwise. On car line streets, unless other arrangements can be made with the operating department of the company, platforms extending the full length of the car and leading to bridges at the cross walks are provided at all car stops. These landings in turn are protected by a wire guard fence to keep the pedestrians on the platforms and off of the newly laid pavement. Additional foot bridges are provided where necessary

FIG. 3. LAYING CONCRETE PAVEMENT IN CHICAGO.

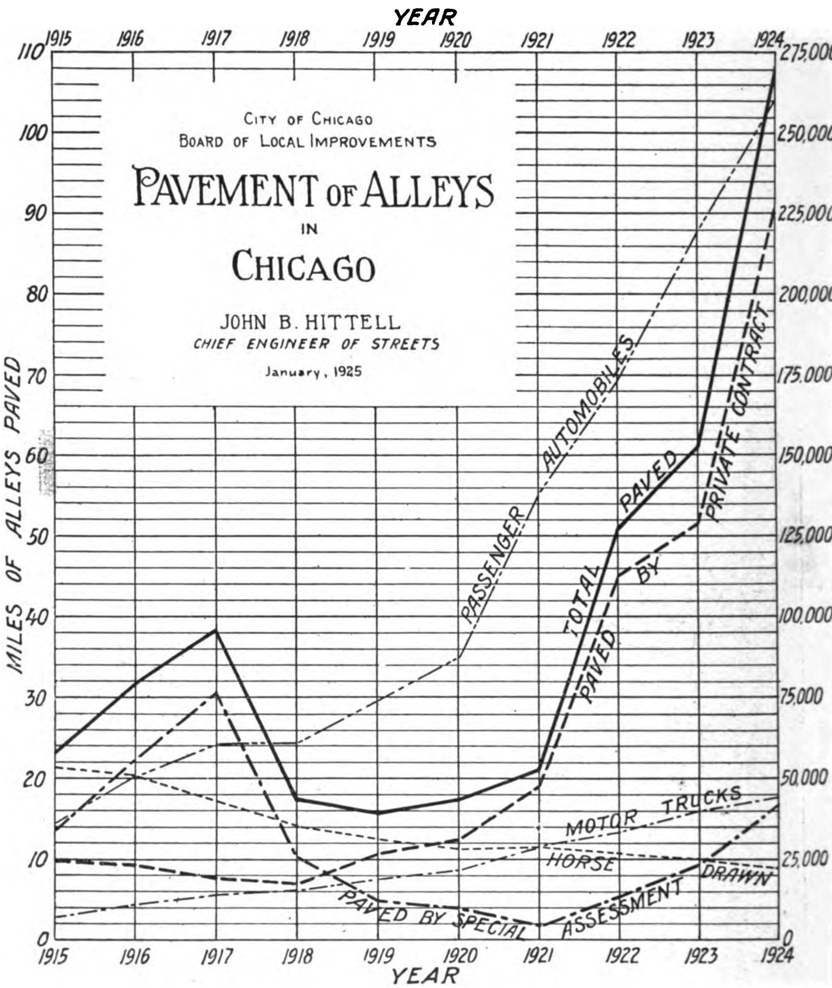

FIG. 4. SHOWING THE INFLUENCE OF AUTOMOBILES ON THE AMOUNT OF PAVED ALLEYS.

at intersections. When car lines are opened to vehicular traffic, this traffic is kept off the new pavement by a cable, chain or railing supported by standards.

Alley Pavements

Referring to the chart on pavements in alleys, the graph shows together with the number of licenses issued for automobiles, trucks, etc. the miles of alleys paved by special assessment and by private contract, and the totals for the years 1915 to 1924 inclusive. Here is markedly depicted the result of war conditions upon public improvements extending through the years 1918 to 1921 and the rapid increase following the improved conditions of the public in general since 1921. If a curve were shown including motor trucks and passenger automobiles the relation of that curve to that of total paved would be even more striking than that of passenger automobiles alone to the curve showing total paved.

Average Prices—1924

	Sq. Yd.	Totals
Asphalt 6-2-1½	3.794	6.333
Asphalt 8-2-1½	4.207	7.293
Asphalt 8-2-1½ with brow paving	4.180	8.403
Asphaltic Concrete 6-2	3.20	5.803
Asphaltic Macadam	3.269	5.907
Brick 6-2-4	5.80	8.621
Portland Cement Concrete 6-2	3.915	6.548
Portland Cement Concret 7-3	4.854	7.741
Portland Cement Concrete 7-3 with brow paving	4.852	9.104
Alley Concrete 7"	2.986	3.864
Alley Concrete 7" with sewer	3.00	5.036

Last year the number of alleys paved by special assessment was 132 and the number paved by private contract was 741 making a total of 873 alleys paved by this department in 1924. A mile of alleys requires 9000 square yards of paving. The business of alley paving has grown to large proportions and in the main is conducted by those who are well equipped by a thorough organization and up-to-date mechanical appliances and adequate capital. At times adverse criticism is made to the practice of issuing permits to pave by private contract. In order to obviate or reduce these to a minimum, rigid regulations have lately been put into effect. The custom is sanctioned by law and the means to an end is justified. The large number of alleys so paved obviates the expense of special assessment procedure, which in the case of actual monetary expense to the City of Chicago, in advertising, postage, and court costs, exclusive of engineering and clerical work is almost twenty dollars per alley. If this alley paving were all done by special assessment proceedings, important street paving projects would be curtailed or delayed unless a great deal larger force were provided. A small revenue also accrues to the city from the inspection fees which are paid by the contractor.

PAVING—BOARD OF LOCAL IMPROVEMENTS—1924

Special Assessment

MATERIAL	Streets		Alleys	
	Sq. Yds.	Lin. Ft.	Sq. Yds.	Lin. Ft.
Asphalt	1,020,600	308,879		
Asphalt—Type B	36,416	10,462		
Brick	57,757	21,136		
Granite Blocks	12,579	4,000		
Asphalt Macadam	106,775	29,575		
Concrete	138,173	45,547	155,320	88,419
Asphaltic Concrete	77,523	24,099		
Asphaltic Concrete—Willite	20,788	8,190		
Sandstone Blocks	8,878	600		
	1,479,489	452,488		
		85.698 Mi		16.746 Mi

Private Contract

MATERIAL	Streets		Alleys	
	Sq. Yds.	Lin. Ft.	Sq. Yds.	Lin. Ft.
Asphalt	48,950	14,922		
Asphalt—Type B	8,653	3,245		
Brick	200			
Granite Blocks				
Asphalt Macadam	23,072	7,109		
Concrete	2,645	1,070	823,624	484,396
Asphaltic Concrete	13,981	4,993		
Asphaltic Concrete—Willite				
Sandstone Blocks				
	97,501	31,339	823,624	484,396
		5.935 Mi.		91.741 Mi.
Grand Total				200.12 Mi.

The table shows the average unit price bid during the year 1924 per square yard for the various pavements indicated. The column at the right shows the average total cost for the various types per square yard including all collateral operations such as grading, curbing, sewer adjustment work, sidewalk connections, etc.

With an engineering force of eight division engineers, eight junior engineers, and twenty-four rodmen, aside from preliminary work for this year, there was executed under them the mileage of pavements shown in the table on the preceding page. This represents an expenditure of approximately thirteen million dollars.

In general our present practice tends toward stronger pavements, with wider roadways and flatter crowns combined with the general practice among highway engineers of a more rigid selection and proportioning of materials, and better workmanship.

Resurfacing and Widening Existing Pavements

By A. J. Schafmayer*, M. W. S. E.

Presented, February 24, 1925

Existing traffic conditions have rendered many of our present pavements inadequate or unfit to meet the demands made upon them. The effort to meet these demands and conserve the original investments so far as possible has resulted in a considerable increase in the widening and resurfacing of existing pavements.

Resurfacing Pavements

RESURFACING projects receive a careful analysis before being approved for construction. It is not considered necessary, however, that the same standards of design and endurance should be applied to a resurface project as would be applied to an entirely new paving project. The ordinary resurface pavement is not expected to last as long as a new pavement. We do not expect it to be as well designed as if it were entirely new, whether considered from the standpoint of comfortable and safe riding qualities, surface drainage or appearance. The original improvement is such an essential part of the new one that the new one should properly retain many of the characteristics of the original even though they might not be tolerated in a completely new design. It might very properly be asked, — if resurfacing is not completely satisfactory, why consider it at all? The principal reason for considering it is economy. Resurfacing, if physically advisable, will undoubtedly result in a considerable initial economy. The exact amount saved varies of course with the individual conditions. In addition to this lower initial cost there are these further reasons for the property owner desiring to have his pavement resurfaced rather than rebuilt entirely. By postponing new construction ten or twelve years he may take advantage then of new and better types that may be developed. Also there will probably be new economies developed in construction machinery and methods of operation. And there is also a reasonable chance of a reduction in the cost of materials and in freight rates by that time. And finally he may sell his property and let the new owner pay for the more expensive pavement. These reasons explain why the demand for resurfacing is unusually strong at the present time. The initial economy, however, is sufficient to create a popular demand for resurfacing in the majority of cases without any further consideration, so that the question of resurfacing is usually confined to the physical possibilities.

In considering the physical advisability of resurfacing old pavements in Chicago we have two general cases. 1. Those within two or three miles of Lake Michigan which have a sand sub-grade, and 2. Those lying farther west which have a clay sub-grade. The same methods are

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used in studying either case. But in studying the advisability of resurfacing old macadam pavements, a greater minimum depth of old macadam is considered necessary in the second case than in the first.

In studying these pavements the old surface or wearing course requires consideration as to its influence on the quantity of material to be removed, or whether it can be retained, in which case it is considered as a part of the base. The old base or foundation should be generally sound, not ravelled or seriously depressed, and should have old replaced cuts and openings in good condition. It should also be of such general depth and cross section that the old base and the new surface can be made to conform to each other. This must be done without disturbing the established curb grade or damaging existing improvements. These last conditions require the greatest study and are frequently the cause of the rejection of an otherwise feasible resurfacing project.

The difficulty of successfully conforming together the old and the new lies in the fact that in the earlier days of pavement construction, crowns that would now be considered excessive were regularly used. This is especially true of the old water bound macadam type. The problem then, after all other requirements are met, is to place a surface with a comparatively flat crown on a base with a steep crown, keeping the new gutter a proper distance below the established curb grade and at adequate slopes for surface drainage, without removing so much of the old base as to destroy its capacity for supporting loads beyond a reasonable limit. The supporting capacity being a function of the thickness, the minimum remaining thickness is considered as the deciding factor. This minimum thickness is usually set at seven inches for a sand sub-grade, and at eight or nine inches for a clay sub-grade.

Field Surveys

The preliminary work of our studies for resurfacing consists of detailed field surveys. These vary considerably in some features, depending on the kind of material in the old pavement. On surveys for resurfacing old water bound macadam, which is the most common case, we first make test cuts or depth cuts in the pavement at each summit and inlet, at the crown and quarter points. The cuts are usually staggered back and forth across the street. The inspector records these measurements of depth in these cuts on blank forms, each cut being located by number and distances, and shown in its relative position on a sketch which is part of the form. Notes are also made as to the thickness of the oil mat or surface course if any, and any other pertinent detail such as the base being of the Telford type or of slag, etc. The rigid types such as brick, granite and concrete do not require such extensive cutting, but general depth and nature of base should be known.

The level party makes a survey showing the cross section of the surface of the pavement at each summit and inlet, or break in grade, with readings on the curbs, gutters, quarters and crown. Care is used to have the quarter and crown elevations taken at the location of the test cuts as previously reported.

Fig. 1 shows resurface cross section studies.

Office Studies

From this information profiles and cross sections are platted. With the type of wearing surface having been decided upon and its allowable crown, the depth of gutters then determines whether additional material must be added or the old material removed. In the case of macadam pavements, it is usually necessary to remove part of the old pavement, while with the pavements of unit parts such as brick or granite block, additional material is frequently necessary. If the trial design results in a deficiency of material in the old foundation, sometimes a change in the design by shifting summits and inlets, or increasing the crown or raising the entire surface will make it possible to secure the minimum thickness of the old base. The case shown in Fig. 1 was improved by raising the entire new surface one inch which involved a longitudinal shift of adjacent summits with the consequent rechecking of their cross sections, and by changing the new surface from a circular arc to the arc of a parabola, which raised the new surface

at the quarterpoints an additional ¾ inch. Such changes sometimes require the sacrificing of the existing curb and gutter, and part of the old drainage system.

In this connection it is interesting to note that the designer has more latitude or room for adjustment or juggling the gutters up and down, on the older pavements laid from twenty to thirty years ago, than on the more recent ones laid within the last fifteen years. This is probably due in part to a report made in 1904 by John W. Alvord on Chicago Pavements in which he urged the design of pavements with shallower depths of exposed curb face. This recommendation combined with the general tendency of engineers for economy in design has gradually resulted in our modern practice of designing pavements with exceedingly shallow curbs. When such pavements come up for a resurface study about all that can be done is to remove the old surface and replace it with a new one of the same shape. Fortunately, these more recent pavements are generally of such cross section that this can be done.

Where the old pavement has the vertical type of curb without gutters, it has frequently been found advisable to build a new concrete gutter in front of the old curb.

It is worthy of note that there is a growing tendency among paving engineers at present to consider the future resurfacing when designing a new pavement. On brick, concrete and stone block pavements drainage systems are being designed with exposed curb heights sufficient to allow for a new surface to be superimposed without removing any of the original pavement. I have also heard of one city, Champaign, Ill., George Lohman, city engineer, where provisions have been made in a new street railway franchise for meeting such future resurfaces with the street car rails. In view of our present and probable future paving practices this feature should receive careful consideration from public authorities in preparing new ordinances for street railway franchises or for their extension.

Where old pavements are resurfaced the asphaltic type of wearing surface is generally used. This is a very satisfactory material for resurfacing because it

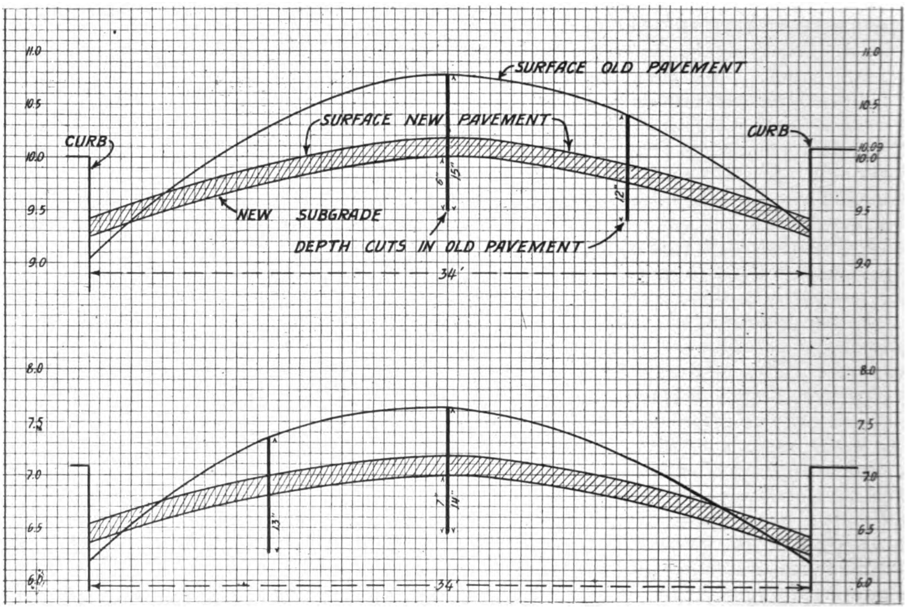

FIG. 1. STUDIES MADE OF OLD PAVEMENT TO DETERMINE CROSS SECTION FOR NEW WORK.

can be laid in a thin course and can be very readily adapted to the various conditions encountered in resurfacing. Any deficiency of material is provided for by a thicker binder, this being a modified black base. This material is also used for filling surface depressions and reshaping certain portions of the original pavement. While it is desirable to lay the binder upon the undisturbed base, still because it is necessary to disturb the existing base by openings for rehabilitating underground utilities, we must provide for considerable repairs to the old base. Such repairs are usually made with the same type of construction as was used in the original base.

The Estimate, Ordinance and Specification

While the studies are worked out in considerable detail these details are summarized in the official estimate in order to avoid new descriptions or phrasings which have not been passed on by the court. So far as possible each item is made identical with or described as nearly parallel as possible, with similar items in our estimates for new construction.

The ordinances necessarily must be more specific than the estimate but in accord with the principle applied in new construction all operations and descriptions are grouped as far as possible and are covered by standard or previously adjudicated descriptions and phrasings. A recent example which presented some difficulties was one system to be resurfaced which consisted of an asphaltic concrete resurface on old macadam in part and included a part where the roadway is to be widened ten feet on each side. The latter required a new base of surplus old material from the balance of the street, black base or binder, and new top. A part required new concrete gutter in front of old sandstone curb. Another, new curb and gutter of standard cross section. Another, new curb and gutter of a special cross section and another, curb and gutter patching of a special cross section. Some intersections were excepted. Some were to be widened and adjusted, some to have long radius curb corners in place of sharp curb corners, requiring new pavement and old pavement adjustment; all including the necessary sewer adjustment. These were all reduced to practically standard descriptions and it is confidently expected that no legal attack can be successfully made upon the project on the ground of any deviation or variance from the legally approved forms.

After the assessment has been confirmed in court, specifications are drawn to cover the work in complete detail. The general printed specifications for new work are used as a basis but are modified and amplified extensively to cover the particular improvement.

Construction

Resurfacing of pavements should be done by experienced men. It is the writer's opinion that the supervision of an experienced foreman especially, is more important on resurface work than on new construction. Inexperienced men make the most deplorable and ridiculous blunders. I had one experience of a green foreman suddenly moving in on a street and attaching rooter plows behind steam rollers and ripping up two blocks of a macadam pavement before he could be stopped. While the contractor then spent an extra week attempting to restore it, it was manifestly impossible to secure the compactness it had received during almost thirty years of traffic. Likewise competent inspectors should supervise resurfacing work and the inspector should have frequent opportunities to consult with the engineer. The numerous irregular developments encountered render this a necessity.

The advantages of resurfacing are: economy, less disturbance of existing improvements, and less controversy.

Economy

a. The financial economy of resurfacing results from a saving on the pavement per square yard due to the saving of the cost of a new base. This is partly offset by the cost of preparing the old base. There is frequently a saving in the item of curbing. A material saving is usually effected in the item of sewer adjustment and new sewer appurtenances. An important saving is also found in the cost of excavation and the disposal of excavated material.

An economy of time results from the fact that each block is thrown open to traffic as soon as it has been reshaped

to receive the surface so that the street is open for use for all but a few days of the construction period.

b. Where a street is resurfaced and the old curbs are used, the old curbs, carriage walks, lawns, drives, sidewalks and intersections all meet and are practically undisturbed. Where a new improvement is made nearly all these require adjustment, due to alignment, settling out of grade, or some other irregularity.

c. There is less controversy over resurfacing. The roadway width usually remains the same. There is rarely any argument about narrowing or widening. There is seldom any argument over the type of surface, asphalt being generally acceptable. And finally there is usually less opposition to the improvement in court because the public is strong for resurfacing.

Disadvantages

a. The Engineering work is more laborious and more expensive, as previously shown.

b. There are more uncertainties. It is a common thing to have something uncovered that requires a change in the plan or the removal of part of the old pavement and its replacement with new.

c. Old errors in alignment or grade and displacements of existing improvements are continued for a number of years. (This is listed as a disadvantage which it is from the standpoint of the general public or the engineer, but it is not considered as such by the individual affected.)

d. It often continues an old inadequate system of drainage and an obsolete design which should be remodeled and there is an uncertainty as to the strength and durability of the completed improvement.

Widening Pavements

The demand for wider roadways comes in connection with the work of the Chicago Plan Commission, requests of motor and traffic organizations, improvement associations, and the desire of property owners in individual cases. Fig. 2 shows Clark street looking north from Ridge avenue, which was resurfaced and widened.

Roadway widening was formerly considered only when it was found necessary to repave a street. Now, however, owing to the demands created by the tremendous increase in motor traffic it is found necessary to widen pavements which have been in service only a comparatively few years. A few examples are given below:

These are typical examples of pavements with widened roadways which had the old surface utilized to as great an extent as possible. Numerous others have had the roadway widened, or are under proceedings, without attempting to utilize the original surface, but which utilize all or part of the original base. A very interesting example of this type is Ashland Avenue from Devon Avenue to Pratt Avenue which is under proceeding for widening from 30 feet to 56 feet. Another is Chicago Avenue from Clark Street to Larrabee Avenue under proceedings to be widened from a 50-ft. to a 70-ft. roadway. This is an old brick pavement laid in 1899. The street railway tracks are of permanent construction and are below curb grade, while the sidewalks are either at grade or above it. This requires a different design as will be shown later on.

North Clark street roadway was widened in 1924 from 42 feet to 94 feet. In this case none of the old brick pavement which was laid in 1908 could be utilized. Other typical examples of projects under proceedings where none of the old pavement can be salvaged, or where only a fractional slab of the old foundation can be used are Indiana avenue, from 15th to 22nd street and 22nd street from Calumet avenue to Archer avenue. In these cases the street will be widened 54 feet on one side only and the present 38-ft., 48-ft. and 53-ft. roadways will be widened to 88 ft. For most of their length the street car tracks now in the center of the

Street	From	To	Year Paved	Material	Old Rdway	Year Widened	New Rdway
Western Av.	Lawrence	Foster Ave.	1915	Brick	42 ft.	1923	60 ft.
Western Av.	56th St.	63rd St.	1915	Brick	50 ft.	1924	70 ft.
Western Av.	63rd St.	71st St.	1917	Brick	50 ft.	1924	70 ft.
Ashland Av.	75th St.	87th St.	1918	Asphalt	*50 ft. †42 ft.	1924	70 ft.

* North of 79th St. † South of 79th St.

old street will be moved over to the center of the new street.

Studies for Widening

Field Survey.

Very careful surveys are made for aid in studying widening projects. The studies of the engineers on the north end of Western Avenue were based on roadway cross sections with level readings taken at one-foot intervals across the surface. On the section between 56th street and 71st street, we used similar cross sections but the readings were spaced two feet apart. On the Ashland avenue project similar sections were used. Fig. 3 is a typical cross section for widening studies.

plied to the old one. Trial transverse surfaces for the widened portion are drawn in and the most feasible ones chosen. These are then checked for the longitudinal gradients in order to assure proper drainage. The surface is again determined where the gradient is found insufficient. When these surfaces are determined the points of tangency or of intersection of the new surface with the old determine the distance out from the old curbs over which the old pavement must be removed and relaid or replaced. These distances are shown on the contractor's and inspector's working plans and are followed carefully during construction. The sections also show

FIG. 2. NORTH CLARK STREET WIDENED READY FOR RESURFACING, OLD TROLLEY SUPPORTS NOT YET REMOVED.

Our sections were taken at each summit and inlet with special and diagonal sections at street intersections. It is also necessary to note all poles, walks, driveways, conduits, buffalo boxes, meters, and basement vaults with coal holes, manholes or trap doors in the portion of the sidewalk or lawn to be occupied by the widened roadway.

Office Studies

These items are platted and studied. The section of the new roadway is applied to the old one.

graphically the additional concrete necessary to bring the old base up to its proper contour for the new roadway.

A slightly different method of controlling the distance that the old surface should be removed was used by the engineers on the Ashland avenue project. Because of numerous irregularities between summits and inlets which would not show on the cross sections the "cut back distance" was not shown on the working plan. Instead the longitudinal

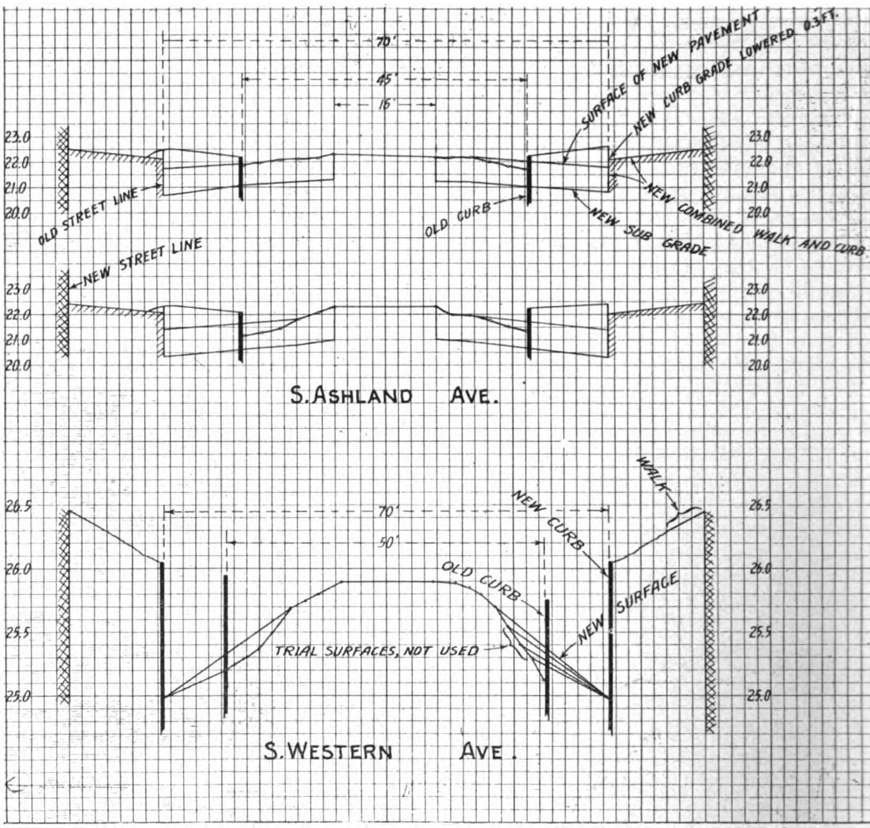

FIG. 3. TYPICAL CROSS SECTIONS MADE FOR STUDYING STREET-WIDENING PROJECTS.

gutter slopes were determined and shown on the plan. Then the construction gang used a tight line drawn from the crown to the gutter elevation shown on the plan. The point of tangency with the surface was marked and the surface cut back to that point.

The first method will probably be the more economical in years of pavement replaced while the second will be likely to give better gradients and slopes and produce a better appearing surface, but will require replacing more old pavement. In either case the new surface will be a series of warped planes rather than warped parabolas or warped cylinders.

Construction

The construction follows the ordinary paving methods. The principal items of any difference to note are these: The importance of cleaning up all debris, filling all ditches and keeping the thoroughfare open, as the old roadway is used constantly while the construction proceeds. The necessity of protecting the workmen from traffic is very important. On streets with such dense traffic that it is necessary to widen the roadway this traffic is a serious danger. The same danger is encountered by the survey parties taking cross sections. Motorists are frequently so reckless and impatient of restraint that it may ultimately be necessary to assign uniformed policemen to protect workmen on such work in a way similar to that of the railroads who send out flagmen to protect their men. An item to check carefully where the surface is brick is the width of the individual brick. It should be equal to that of the original or the courses will soon be out

of line or they will not "notch in" to the old surface. A difference of only one-sixteenth of an inch, such as might frequently occur in repressed brick by a slight film of clay or sand adhering to the button part of the mould and thereby flattening the button on the finished bricks, will cause serious trouble in a project of this type.

Another item of importance on a brick surface and the one where I probably made the most serious mistake on Western avenue concerns the time when the last two lengths of brick may be removed adjoining the junction between the undisturbed part and the relaid part of the old pavement. The old bricks should not be removed closer than the length of two bricks from this line until the day the new bricks are to be placed. In this case the fine grading gang ahead of the concrete gang was permitted to remove the old bricks up to the line. The old brick pavement then stood with these ragged edges while the concrete was laid and allowed to set; and in certain portions several weeks elapsed before the new bricks were laid. The pavement all this time was carrying a dense traffic including the heaviest trucks. The pounding and vibration of this traffic loosened or disturbed the old sand bed under the outer bricks to a certain extent. Generally this was not apparent to an observer. In the few cases where displacement was observed the bricks were removed or the sand bed was tamped up under them. In all cases the new pavement was joined flush and smooth with the old surface. However, after a few months of pounding under the traffic numerous places showed a slight settlement of the sand bed under the last brick or two in the old surface. This condition would probably have been avoided if the last two bricks in each row had not been removed until just ahead of the gang laying new brick. After widening, the surface of the old brick was cleaned and then received a top dressing of hot asphalt and torpedo sand.

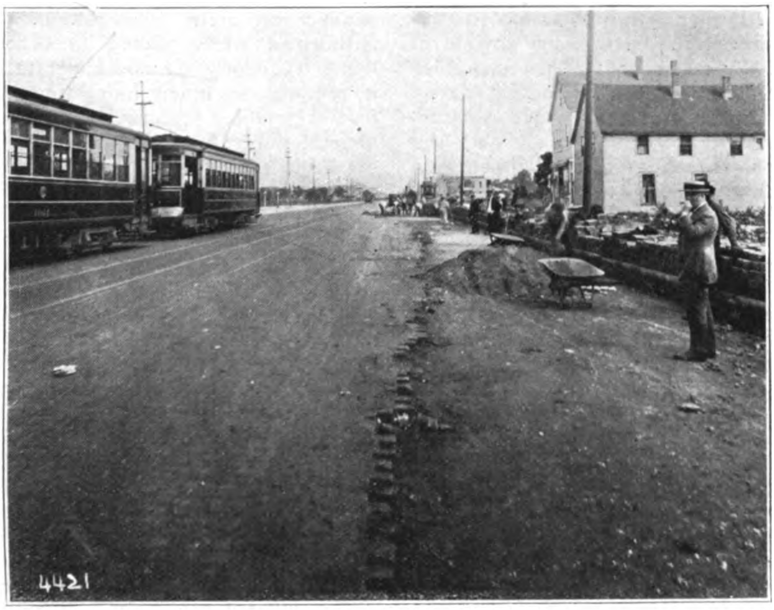

FIG. 4. WIDENING SOUTH WESTERN AVENUE.

General

The general design for widening existing roadways followed mainly in Chicago has been that of a crowned roadway with gutters at the curbs. The general design which leaves the old gutter undisturbed and carries the newly widened portion up to the new curb on a rising slope and

gives the curb a very shallow exposure has been considered but has not been generally used except on Chicago Avenue from Clark Street to Larrabee Street as previously described, and on the proposed widening of Ogden Avenue from Randolph Street to Roosevelt Road where similar conditions exist. This design has the advantage of being more economical and permits widening a roadway with a low street car track and general surface including gutters, and with high sidewalks, in such a way that the high steps at the curbs are eliminated. There are certain objections to it, however. One is the slight wavy effect it may have on traffic. Another is the objection to having the gutter in the traveled portion of the roadway on account of the unsightliness of accumulations of debris. Also because of the fact that where obstructions form pools by backing up the water these pools are a greater detriment out in the traveled way than adjoining the curb. Another point of influence against this design is the fact that the general appearance of this type of street is not as pleasing as the continuous crown type. However, this type is a practical necessity in such cases as these just described.

A feature of the general design that has been under consideration is that of making the widened part of the pavement of a lighter section than that of the main roadway. It is held that since this strip along the curbs is largely used for standing traffic or parked vehicles such a lighter section would be justified. A detail which has been suggested in this connection, if the design using the original gutter were adopted, has been to build this addition at a slightly higher elevation than the original surface. The connection with the old surface near the gutter would be made with a two or three inch bevel or short-radius curve. This slight rise would serve notice, in a manner, to all drivers that the outer portion is not one of the main traffic lanes. And yet where it would be desirable to turn out for temporary use or for parking the slight rise could be readily mounted by any automobile. While this type offers several obvious advantages it has not as yet been selected for any project by the Board of Local Improvements.

Conclusion

Utilization of old pavements by resurfacing and widening are two phases of Highway Engineering that are being forced on engineers by the economic and traffic demands. The engineers engaged in the pavement industry have been reluctant to attack these phases of their work because they mean more work and more detailed study for the same output, or a much poorer showing in quantity or results compared with an equal effort expended on new construction. Public authorities while willing to order such work frequently do not understand why it requires so much more time and effort to produce satisfactory results. The general public has not the slightest idea of the increased work required and does not give it a thought It simply wants the work done right. But the general public, because of traffic conditions, is properly demanding more work of the resurfacing and widening type, and rightfully expects economy and ability in its design and execution. Furthermore, our more permanent and durable types of pavement foundations which have been common in the last fifteen years are inevitably leading us to a constantly increasing volume of such work. The engineers should face it squarely. The decision as to whether the old pavement can be utilized in a new improvement usually falls on the engineer. This is because he is expected to have training, skill and judgment for gathering the facts and figures, and classifying and studying them in their proper relationships to determine the correct method. Everyone knows that half baked projects lead to trouble and bring discredit to a worthy field of construction and to the engineering profession. For these reasons, the engineers should insist on sufficient time and adequate and competent staffs to produce thoroughly-worked-out studies and plans for either resurfacing or widening projects.

DISCUSSION

John A. Dailey (M. W. S. E.): Chicago's Paving Practice, as discussed by Mr. Hittell and Mr. Schafmayer, gives a good general idea of what the city is doing in the way of original construction. The problem, however, does not end

there. After the Board of Local Improvements builds the pavements they are turned over to the Commissioner of Public Works for maintenance, which work to my mind is quite as important as the original work. In fact it is generally recognized that the maintenance problem is no longer of secondary importance.

Chicago last year spent approximately $3,000,000 for the repair and maintenance of street pavements. This year the appropriation amounts to a little over $3,500,000.

There are about 2370 miles of improved streets in Chicago, or about 70% of the total street mileage and 510 miles of improved alleys, or about 28% of the total alley mileage. If we calculate an alley pavement as one-half of the width of a street pavement, there are, approximately, 2600 miles of pavement of an average width of about 30 feet to be maintained with 3½ million dollars, or approximately $1350.00 to the mile.

This amount of money is not sufficient to maintain all the pavements properly, and until such time as the maintenance catches up with the wear and tear on the pavements, or until such time as many of the streets now under maintenance are repaved, the demands on the vehicle tax fund are and will be excessive. I cite these figures just to give an idea of the demands of present day traffic.

To discuss Chicago's street maintenance problem fully one must consider the many types of wearing surfaces; the different types of foundation, and soil conditions. This would require a paper of considerable length and more time than is at my disposal, so I want to bring out just one feature of construction which is the source of much of our maintenance trouble, and which has been, in the last two or three years, a subject of intensive study and investigation by the United States Bureau of Public Roads; State Highway Departments and many cities. I refer to Sub-Grade.

The first essential of any construction project, whether it is a highway, a building, a bridge, or what you will, is to carry the load through the foundation to a stable, durable and lasting sub-base. Heretofore, the tendency was to increase the thickness of the foundation in order to gain the necessary beam strength to carry the load over the weak spots in the sub-grade. Placing a greater depth of concrete will help in spreading the load over a greater area, but this method is expensive and if the soil is one which has a considerable increase in volume due to an increase in the water content, this will not wholly relieve the trouble as the swelling of the soil will heave the heavier concrete about as readily as it will the lighter.

The soil conditions in Chicago are, generally speaking, of two kinds. Along the lake and for several hundred feet inland, the sub-grade consists of sand, while farther west as we approach the divide between the St. Lawrence and Mississippi watershed, we find a large percentage of clay in the soil.

Where the clay exists is where we find our greatest maintenance trouble, due to so-called foundation failures. In my opinion, it is not so much of a foundation failure as it is a failure on the part of the sub-grade to remain permanently in place. In other words, the swelling of the soil, due to its moisture content, disturbs the foundation.

Recent experiments have shown that this moisture content is divided into two parts. First: That which can be removed by the sewers or by the placing of drain tile at intervals sufficiently frequent to drain the soil. This is called gravitational moisture. Second: That which is retained in the case of a moist material or drawn up in the case of a dry material by capillary action. This is called capillary moisture.

It might seem at first, that the use of drain tile at more frequent intervals would prevent the rise of capillary moisture but in recent research work, conducted by the State Highway Department of North Carolina jointly with the School of Engineering of the University of North Carolina, has demonstrated that drain tile do not remove or prevent the rise of capillary moisture, but that the percentage of capillary moisture is reduced as the elevation of the sub-grade above the water-table is increased.

In the case of clay against the under side of a concrete foundation, a small difference in temperature between the clay and the concrete causes a condensation of moisture which, in cold weather,

freezes and thus adds to the volume increase and consequent heaving of the pavement.

To overcome this condition a layer of porous or granular material, such as sand, gravel or cinders spread over the subgrade has been found to be an effective agent in preventing the rise of capillary moisture, and this granular layer itself is not harmfully affected by the condensation resulting from changes in the temperature. It has been further demonstrated that the layer of granular material is effective in preventing the penetration of a plastic sub-grade up through a broken stone or gravel road.

The effort to prevent the rise of capillary moisture has been confined, largely, to the use of a granular layer from two inches to five inches in thickness placed immediately over the sub-grade. Studies are now being made to determine the proper thickness.

While it is recognized that the thickness of the granular material will vary with the character of the soil, it occurs to the writer that the maximum thickness, as before mentioned, might be considerably reduced by the use of a bituminous material mixed with the granular matter. No doubt experiments of this kind will soon be conducted.

The writer knows of only one street in Chicago where a granular material was placed over the sub-grade with the object of preventing moisture from reaching the foundation. This was done on the north drive of Garfield Boulevard from Normal avenue to Western avenue by the South Park Commissioners in 1922. The subgrade was a very treacherous clay. The street was excavated to a depth of 16 in. and an 8-in. layer of cinders placed over the sub-grade. On this was laid a 6-in. Portland Cement concrete foundation and a 2-in. asphaltic concrete wearing surface. The pavement is in good condition at the present time, and I am advised by the Engineering Department of the South Park Commission that there has been no maintenance or repair cost to date.

Should it be fully demonstrated that the use of a relatively thin layer of granular material placed over the subgrade will add the necessary stability to the foundation under pavements, the advantages of this method of construction over the proposed method of increasing the thickness of the foundation, are readily seen. If we compare a 6-in. concrete base laid over a layer of sand, say 3 to 4 in. thick, with an 8-in. concrete base, without the additional sand layer, the former would, in my opinion, cost considerably less. There would be a slight additional cost of excavation, due to the greater depth, plus the cost of purchasing and spreading the granular layer, but this cost would not equal the cost of the greater concrete thickness.

Or, we might compare an 8-in. base laid over a granular material with a 10-in. base, without the additional layer, and again the cost would favor the lesser base thickness.

I mention 6, 8 and 10-in. base because all of those thicknesses have been laid in Chicago.

Should we go further and compare a concrete base laid over a granular material with a reinforced concrete base (the latter method of construction has frequently been suggested) the difference in cost of construction is more pronounced. This is particularly true if we consider the maintenance of the public utilities laid in the streets. All the utilities must, of necessity, be repaired, overhauled or enlarged from time to time. To do this, the pavement must be cut through, the utility repaired and the pavement restored to its original condition. Every inch of concrete added to the foundation adds to this cost, and should it become necessary to cut through and restore a steel reinforced foundation, the cost would be still greater.

The foregoing comparisons are made to bring out what may be accomplished through research work in highway construction. Only in recent years have any extensive experiments been made, and only very lately has particular attention been given to the subgrade. The City of Chicago has two paving laboratories in operation, but the large amount of construction work in the Board of Local Improvements and the Bureau of Streets keep the technical forces fully employed with their everyday work. With the large amount of money spent in pavement construction and maintenance in the city of Chicago, it appears to the writer that a small percentage of the

available funds could be wisely and judiciously appropriated for research and experimental work. If conducted by competent engineers and chemists, such work would result in lowering the cost of pavement maintenance.

John J. Sloan (President, Board of Improvements, Chicago): The present plan of building streets with the crown in the center and sloping towards each gutter is open to sundry objections. It was started when open ditches on each side of the road were the only means of drainage and before underground sewers were in use.

Water and refuse accumulate in the gutters and people getting in or out of cars, or vehicles delivering merchandise, are obliged to pass through or over it. Extra catch basins must be provided to properly drain it, with the attendant expense of drain tile connections to sewers in the center of the street. Iron covers over these basins are frequently in the line of travel, wearing smooth and becoming tilted or distorted. Due to the fact that these trenches between connections are usually made a few days before the base of the pavement has been laid, settlement is constantly taking place. The pavement frequently sinks a little later, causing numerous depressions. This is also due, in a large measure, to underground connections not having been thoroughly compacted. Traffic alongside these gutters, when the streets are wet, is the cause of constant complaint of spattering mud on people on the sidewalks.

Automobiles and other rubber tired vehicles being obliged frequently to drive in and stand in water, accumulated in gutters during our rainy and winter seasons, undergo damage that trade officials in that line estimate amounts to an annual loss of $5,000,000 or more.

It is suggested, in lieu thereof, that a pavement be built dished instead of crowned, or of a concave type instead of the present convex type, with the catch basins down the center of the street, draining direct to the sewers and the pavement sloping from the sidewalk edge to the center of the street, thus carrying all water direct to the inlet connections over the sewer. No curb will be required where the sidewalks come to the curb line; no gutters required, which are too frequently used as a catch-all for refuse which should be disposed of elsewhere; no drain tiles required; no excavations to be made and no excess material to be removed—a uniform curb line along the street, which, with summit crossing, would obviate the constant stepping up and down in a few blocks of travel. In addition to this—a line of basins down the center of the street would tend to operate as a dividing line between traffic and tend to minimize accidents.

The smooth surface pavements of asphalt or concrete, which largely predominate, require very little grade or slope for drainage and the change proposed would more nearly resemble a plane or flat surface.

The cost of such construction should be at least fifteen percent below that of our present type, besides making for a more sanitary condition, expediting work, lessening accidents and, possibly, presenting a better appearance.

As few horse-drawn vehicles are now in use, the streets are not littered as formerly and oil and gasoline droppings have replaced them. All alley construction in the City of Chicago at present is on this concave plan.

This would not apply to traction line streets.

C. R. Ege (M. W. S. E.): This discussion refers to that portion of Mr. Hittell's paper which mentions the effect of temperature upon Portland cement concrete as used in pavements in Chicago.

The effect of temperature on concrete pavements has been extensively studied by the U. S. Bureau of Public Roads, the U. S. Bureau of Standards, several of the State Highway Departments, and the University of Illinois.

Mr. Hittell mentions the approximate amount of linear change per 100 feet which may occur in concrete pavements or bases due to the maximum range of temperature. This range is shown to be approximately 140° F. in Chicago.

The actual dimensional change of concrete due to temperature, as determined by laboratory investigations, is of course greatly modified by other factors present or surrounding its use in pavements. Moisture is the most important of these factors; others, also of importance, are

the temperature at the time the concrete is mixed and placed, and the resistance of the subgrade due to friction and the inertia of the slab itself.

It has been established that changes in moisture content of hardened concrete produce changes in volume; and that an increase in moisture content is attended by increases in volume. These conditions may offset volume changes due to temperature, or they may be cumulative. For example, it has been observed that unusual expansion will occur in a long tangent of concrete road when hot weather suddenly follows prolonged wet weather. The expansion and construction joints, natural cracks, etc., will close, and somewhat rare instances exist where the compression developed will exceed the resistance of the pavement. In a pavement not provided with expansion joints, the force developed by the expanding concrete may be localized and cause the slab to buckle. This has happened in Illinois when the right combination of conditions has occurred; the frequency has been limited to one case in approximately forty miles of road. Such a condition rarely occurs on city streets, never when adequate provision, such as Mr. Hittell describes, is made for expansion by means of pre-formed joints at transverse intervals of thirty feet. This spacing conforms to that recommended by such an eminent authority as A. T. Goldbeck of the U. S. Bureau of Public Roads.

Transverse expansion and contraction takes place but is so limited in amount as to be negligible so far as pavement design is concerned.

Unequal changes, due to temperature and moisture, take place in top and bottom of the concrete slab. These are somewhat microscopic in degree, and the pavement designed described by Mr. Hittell provides against these effects by means of the longitudinal separation plates, or so called "hinge-joints." Similar design is standard for concrete road construction in Illinois, following extensive research work under direction of Mr. Clifford Older, and described by him before this Society several months ago. The facts established by Mr. Older have since influenced the design for concrete highways in some thirty-eight states, and are being taken into account extensively by City Engineers in street design. The use of longitudinal dividing planes as described by Mr. Hittell is being followed in the design of the express traffic boulevard now being built between Detroit and Pontiac, Michigan; a distance of about sixteen miles. This boulevard has two roadways, each forty-four feet wide, separated by an interurban track zone forty feet wide. The two concrete roadways are each divided into longitudinal panels ten feet in width by means of the metal division plates. A similar arrangement of dividing planes is specified for the McCormick Road improvement, now under construction by the Chicago Sanitary District, paralleling the North Shore feeder to the Drainage Canal.

The other two factors modifying the effect of temperature changes, viz., frictional resistance of the sub-grade and slab inertia, tend to localize the stresses set up as a result of expansion and contraction. Investigations by the Bureau of Public Roads have determined that the frictional resistance of the sub-grade varies with its material, and its condition as to moisture. A wet sub-grade offers less resistance than a damp but firm subgrade.

Just by way of giving some measure of this resistance, results of some studies by the Bureau of Public Roads may be quoted. In the case of a firm loam subgrade, it was found necessary to apply a force of 86 pounds per square foot of six inch pavement to produce a movement of one one-hundredth of an inch. When this same sub-grade was thoroughly soaked, the necessary force to produce the same movement was approximately 22 pounds per square foot. These resistances are increased of course with sub-grades of harder materials and irregular or uneven surfaces. It is considered good practice to form the sub-grade so as to offer low frictional resistance. At this point, general practice divides; one school of thought is responsible for the use of regular and frequent joints filled with a compressible material, at which the movements due to contraction and expansion are localized, thus relieving internal stresses in the slab. The other school of thought, if we may so term it, provides no joints of any kind. In this case the concrete is designed to be strong enough to resist the compressive stresses.

Some Engineering Problems of the Gas Industry

By Harry E. Bates,* M. W. S. E.

Presented March 17, 1925

In this paper we have a general statement of the problems confronting the management of a large gas company in the selection of equipment to manufacture gas on the most economical basis. The author gives the reasons for selecting the types used in the large gas plant recently built in Chicago and follows with a description of the plant. A more detailed description of the mechanical equipment appeared in this Journal in September, 1922.—Editor.

ONE of the most important subjects before the people of Chicago today is the future of the city and its surrounding communities. The most optimistic statements are made by those qualified to speak with authority on subjects regarding the city's growth and development. Studies are being made by various organizations concerned with the welfare of the city, and it is agreed by all that Chicago is destined to become one of the world's largest cities, and perhaps the world's largest industrial center.

Chicago, a City of Destiny

It is estimated that by 1950 the population of Chicago will be approximately five million, and the Chicago district — including surrounding suburbs — will have a population of approximately six million. Plans are under way to beautify the city and provide the needed facilities to meet the expected growth. The Chicago Plan Commission has developed a comprehensive plan for the future, which includes projects involving many millions of dollars. Part of this program is either completed or in progress of construction. The widening of Michigan Avenue, the development of Grant Park, the South Water Street improvement, the widening of Ogden Avenue, and the Outer Drive to the South Side are some of the details of this project, either completed or under way.

The railway terminal situation is being studied, the transit problem is receiving much attention and subways will eventually be built. In all these projects the engineer is vitally interested. He is responsible for all the planning of these large projects, and the results obtained are real monuments to the engineering profession.

Most of the projects previously mentioned have been discussed before the Western Society of Engineers from time to time. In addition to these developments, other public utilities — including gas, electricity, and telephone — have their problems to meet to provide for growth. While the utilities' problems have not received much publicity, plans for the future are constantly being studied in order to develop their systems along sound engineering lines.

Planning for Future Growth

The planning for extensions and future development of the gas industry must, of course, take into consideration the future growth of the population and the district to be supplied, just the same as the development of other engineering projects must, but in addition to the usual problems connected with the growth, there are some special problems which must be carefully considered. Not only is it necessary to estimate the future growth of the city as to increase in population, but it is just as important to estimate as accurately as possible the direction and intensity of growth.

Population Requirements for Gas Easily Estimated

Developments of the system, when made, must be such that they will fit in with future installations, and a mistake in forecasting the direction or intensity of the growth in population may result in an increase in the ultimate investment over what would be required if the direction and intensity of growth had been accurately forecast.

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New Uses for Gas Limitless

Another important factor which must be considered in the development of a gas supply system is the new applications of gas. It is fairly easy to estimate the future requirements of gas supply necessary for increase in population because this can be estimated from past records. It is not so easy, however, to forecast the additional requirements over and above those necessary for normal increase in population, due to new developments in the use of gas.

In the past twenty-five years the use of gas all over the country has shown a very marked increase. Taking the United States as a whole, the annual consumption per capita has increased from 1310 cu. ft. in 1901 to 3026 cu. ft. in 1921. Statistics for 1924, when available, will show a continuing increase over that of 1921. The possibility of increased consumption in the future is even greater than that of the last twenty-five years.

The use of gas in industrial operations during the past few years has been developed to a remarkable degree and still only a small amount of the available business has been obtained. It has been prophesied that Chicago will become the world's largest industrial center, and this alone will result in enormous uses of gas in the future in the industries. Conservative estimates indicate that by 1950 over 47 billion cubic feet of gas will be used annually for industrial purposes, as compared with 3½ billion cubic feet in 1924.

House Heating with Gas

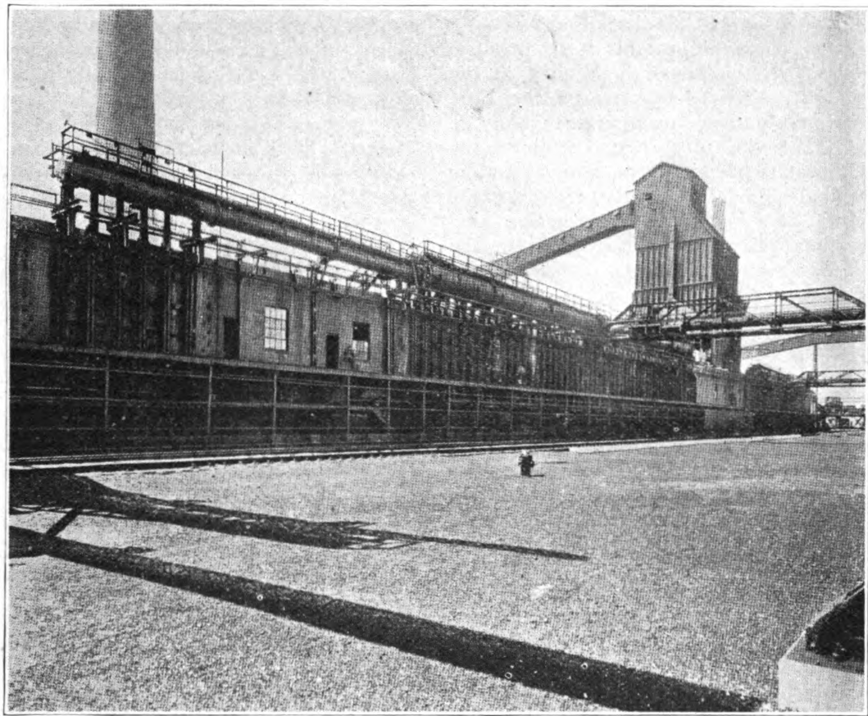
Gas service is rapidly coming into use as a means of heating houses, and this presents a new field with wonderful possibilities. Gas for house heating provides the ideal fuel, with its freedom from dirt and labor, and its general all-round convenience, as compared with any other fuel. Its application to house heating will remove the smoke nuisance with which Chicago and most large cities are afflicted and which must be prevented in order to realize the dream of the Chicago Plan Commission of a city beautiful, and make a more beautiful community to live in. It is estimated that by 1950 more than 25 billion cubic feet of gas will be used annually for house heating, as compared with 300 million cubic feet in 1924.

Facilities Increased by New Plant

It is therefore clear that any plan for the development of production and distribution facilities for gas in Chicago not only must be based upon the normal increase due to growth in population, but must also consider new applications in the industrial and house heating fields. Taking into consideration all factors influencing the future gas supply, it is estimated that by 1950 the annual sales will approximate 125 billion cubic feet, with a maximum 24 hours' output of 545 million cubic feet.

Several years ago The Peoples Gas Light & Coke Company recognized the enormous possibilities for increased demands of its product, and in 1921 a plant for the production of gas was completed and put into operation which may be expanded as conditions demand, to probably the largest plant of its kind in the world. The location of the plant is such that it may be used as the center of all future development to take care of increased demand. It is located at 35th Street and Crawford Avenue on approximately 600 acres of land. This location is about midway of the city's length in a north and south direction, and is far enough west to meet any growth in a westerly direction.

A 48-inch transmission main extends north and south from this plant, to 71st Street on the south, and Irving Park Boulevard on the north. Plans for 1925 provide for the extension of the northern line to the city limits at Devon Avenue, and future plans provide for extension of the southern line from 71st Street to the city limits on the south. In the future, production plants will probably be built on the north and south extremities of this line, thus providing a 48-inch transmission line extending from the city limits on the north to the city limits on the south, with three plants supplying gas to it. The central plant at 35th Street will be the major one of the three, as it is most centrally located. From this transmission line, laterals are taken off to the east and west for distributing gas across the city.



GENERAL VIEW OF OVENS ALONG PUSHER SIDE SHOWING COLLECTING MAINS AND COAL STORAGE BINS.

Types of Plants

The selection of the proper type of production plant to install can only be made after carefully studying the various types of plants available, and all the conditions which influence a choice between these types. At the present time, there are four principal types of plants for the production of city gas, each having its advantages and disadvantages, depending upon conditions which must be met in operation. These four types are:

Carburetted Water Gas
Coal Gas
Combined Carburetted Water Gas and Coal Gas
Oil Gas.

Any one of these four types will produce gas economically under the right conditions. The principal factors which must be considered in making a choice of these four types are as follows:

1. Heating value standard of the gas to be supplied.
2. Cost of coal.
3. Cost of coke.
4. Cost of oil.
5. Market for surplus coke.
6. Market for other by-products such as tar, ammonia, and light oils.
7. Flexibility of operation.

Heating Standard First Consideration

Prior to about ten years ago most state regulatory bodies required that the standard for gas service should be a candle power standard. The development of the incandescent mantle and the application of gas for heating operations made such a standard obsolete. As a result, with the exception of one or two states, the candle power standard has been discarded, and in its place a heating value standard established. The standard heating value in most states today varies between 500 B. t..u. and 600 B. t. u.

It is believed by most gas engineers that it is economically wrong to require gas utilities in various parts of the country to operate on the same standard of heating value. Instead of a fixed standard, the utility should be allowed to choose,

within reasonable limits, that heating value which would permit it to produce the greatest number of heat units at the least cost. This seems to be the only equitable standard to operate under, in order that the utility can produce the product at the lowest cost, and the public obtain the lowest possible rate for the product. Such a flexible regulation permits the utility to adapt its cost to the market conditions of the materials required—especially oil.

Carburetted Water Gas Plant

In carburetted water gas production, the principal fuel required to provide the necessary heating value to the gas is oil. Approximately three gallons of oil are required to produce 1000 cubic feet of gas having a heating value of 540 B. t. u. Oil prices have been subject to wide variation in the past few years, and all indications point to a substantial increase in price in the future. On the basis of three gallons per thousand cubic feet, each 1c increase in the price of oil adds 3c to the production cost of gas.

Two or three states have already recognized the economical advantage of allowing utilities to operate under a flexible standard of heating value, and their regulations permit the utilities within the state to choose that standard which they can produce most economically.

Oil Gas Plant

In California, where cheap oil is available, there are large installations of oil gas plants; these plants utilize nothing but oil fuel in the production of gas. With the exception of that part of the country, the oil gas type of production equipment is not being used, as the price of oil makes such a process prohibitive.

Eliminating, therefore, the oil gas process from further consideration, the two types of plant left for consideration are the carburetted water gas, and the coal gas, or a combination of these two.

Coal Gas Plant

Until about five years ago, water gas production was much preferred, especially in the Middle West. If oil and coke can be obtained at low prices, this method is very economical and has a flexibility of operation not possible in a coal gas installation. However, in recent years the prices of coke and oil have increased to a point where engineers seriously question the advisability of installing a plant of this type. This increase in the price of materials used in water gas operation has resulted in the installation of many coal gas plants. The principal material used in coal gas operation is bituminous coking coal, and the process has been perfected to such a state that it is without question the ideal plant today, from a viewpoint of obtaining the most from our natural resources.

In a modern coal gas installation, the following results may be expected, with a representative grade of bituminous coal. From every ton of coal carbonized, there is produced approximately

12,000 cu. ft. of gas of 540 B. t. u.
1,430 lb. of coke
11 gal. of tar
26 lb. of ammonium sulphate
3 gal. of light oil

From the tar and light oils are obtained many other products.

Neither the water gas nor oil gas process produces the amount of by-products that the coal gas process does, and from a standpoint of conserving the resources of the country the coal gas plant leads them all. However, there are certain factors which must be considered before choosing a coal gas installation of this type for the production of city gas. The economical production of gas depends largely upon the available market for the by-products, especially coke. In certain parts of the country, gas companies would be compelled to compete with private industries for a coke market, and since the utility cannot vary the price of the gas sold, at will, to take care of ascending costs, it may not be possible to dispose of the coke at a profit when competing with private enterprises which are at liberty to vary the price of their principal product. If a utility company can dispose of the surplus coke at a price which would give it a fair profit, the coal gas type of installation as a very attractive one for the production of city gas. The other by-products, such as tar, ammonia, and light oils, must be marketed also, but the marketing of these products does not present the problem that the marketing of coke presents.

A disadvantage of coal gas process over the water gas process is the flexibility of operation. A coal gas plant, especially the oven type, must be operated at a fairly constant rate. The demands upon a gas utility vary widely. For example, in Chicago, the maximum day's output of gas exceeds 128 million cubic feet, while the minimum day's output is approximately 67 million cubic feet. It is evident, therefore, that any plant constructed must be of such a type as to permit its operation at various load conditions. For this purpose, the water gas installation is ideal, as it is made up of a number of individual units which can be put in operation or shut down at will.

Horizontal Ovens vs. Vertical or Inclined Retort Type

There are two principal types of coal gas installations—one, the horizontal oven type, and the other the vertical or inclined retort type. The principal difference between these two types of plant is in the carbonization unit. The other features of the plants are common to both types. The vertical retorts are used very extensively in Europe by gas utilities—more so than the oven type. It is a little more flexible than the horizontal oven and the investment is less. The coke produced in the vertical retort, however, is not as good a quality as that produced in the horizontal oven. The principal market for coke produced by gas companies in Europe is for domestic heating, and retort coke is very good for this purpose. In the United States, however, a large part of the coke marketed is for industrial purposes such a blast furnaces, foundries, and metallurgical uses. This kind of coke can be produced better in horizontal ovens than in retorts, and at the same time the domestic coke is just as good in quality as that produced by the retorts. Most gas utilities in the United States are using the oven type of plant rather than the vertical retort type on account of the quality of coke which must be marketed.

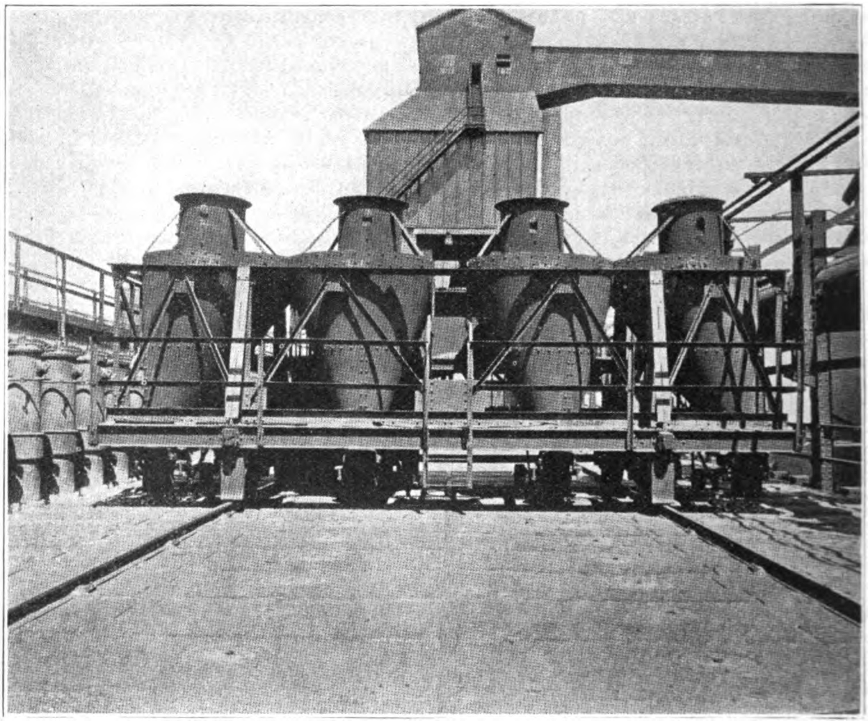
Combination Type, Coal Gas and Carburetted Water Gas

Many gas engineers today believe that the ideal plant installation for the production of city gas is a complete carbonization unit having the essential features of both coal gas and water gas types. Such a plant would make possible the use of cheap bituminous coal, obtain the benefits of coal carbonization, and by completely consuming the coke, free itself from the responsibility of marketing a large amount of surplus coke. Considerable money is being spent today in an effort to develop a unit of this type, but so far it has not reached a finished state. It is questionable whether such a process can be developed in a single stage. It may be that the practical solution of it will be a two-stage process, where the coal is first carbonized—driving off the coal gas and the by-products due to the carbonization—and then the coke obtained by such carbonizing of the coal, used in a second stage where it will be consumed in the production of water gas. This two-stage process may be obtained today by erecting a combination coal gas and water gas plant, which is the type of plant recently erected for The Peoples Gas Light & Coke Company.

After considering all the various factors entering into a choice of plant, The Peoples Gas Light & Coke Company came to the conclusion that the ideal plant for Chicago, was a combination plant which provides all the advantages that the coal gas plant provides—such as recovery of all the by-products—and makes possible the flexibility desired in a plant, by using the water gas plant to take up the variations in demand. It also gives a certain amount of flexibility by making it possible, when oil is cheap, to make large quantities of water gas and curtail coal gas operations if necessary, or, when oil is high, to curtail water gas operations and operate the coal gas unit at full capacity.

This combination type of plant is being installed throughout the United States, probably more than any other type of plant. The same combination plant can be utilized whether the coal gas equipment is of the horizontal oven type or of the vertical retort type.

The Crawford Avenue plant of The Peoples Gas Light & Coke Company is located on approximately 600 acres of land, and has a normal capacity at present of 54,000,000 cubic feet per 24 hours, made up of 24,000,000 cubic feet of coal gas and 30,000,000 cubic feet of carburet-



CHARGING CAR READY TO CHARGE COAL INTO THE OVENS. ASCENSION PIPES AT LEFT.

ted water gas. The original installation had a capacity of 15,000,000 cubic feet of coal gas. In the original installation the ovens were heated by part of the gas produced—approximately 40% of the total gas being used for this purpose. However, the plant was so designed that producers could be installed at any time to provide the necessary gas for heating the ovens, thus making available all the oven gas for distribution.

During the past year the gas requirements of The Peoples Gas Light & Coke Company increased so that it was necessary to obtain additional supply, and last summer producers were installed, thus releasing approximately 9,000,000 cubic feet of additional gas for distribution.

The land occupied by the plant is of sufficient size, and the installation now in operation has been so laid out, that the plant can be increased to an ultimate capacity of 150,000,000 cubic feet per 24 hours or more.

Coal Gas Plant

The coal gas plant consists of 105 Kopper's ovens. One hundred of these ovens are 16 inches wide, 40 feet long, and 11 feet 8 inches high, and have a capacity of 12¾ tons of coal. The other five ovens were added later, and are of the latest Koppers-Becker type. These five ovens are 14 inches wide, 40 feet long, and 11 feet 8 inches high, and have a capacity of 11.7 tons of coal. The coking time on the 100 ovens is from 14 to 16 hours, while the five ovens have a coking time of from 10 to 12 hours.

The ovens are equipped with regenerators for the recovery of waste heat. The heat recovered is used to preheat the air and producer gas required for heating the ovens. These regenerators are filled with checker brick, heated by the waste gases from the combustion flues. At regular intervals the heat which has been absorbed from the regenerators is replaced by reversing the flow. In this

case the regenerators absorb heat from the waste gases from the combustion flues. When the ovens are heated by coal gas produced in the ovens, it is not necessary to preheat the gas. In that case, the regenerators serve to preheat the air only. When using producer gas, however, the low B. t. u. value of this gas requires that it be preheated in order to give the proper flame temperature.

It is very important that the heating of the ovens be properly controlled, as their over-heating would result in serious damage, and under-heating would produce poor quality coke and gas. The proper heating is accomplished automatically by electric reversing apparatus which is connected to a clock movement and which reverses the flow of gas, air and draft every 20 minutes when heating with coal gas, and every 30 minutes when heating with producer gas. A safety device, operated by water pressure, gives a signal in case of failure to reverse due to electrical or any other trouble.

The temperature of the heating flues is approximately 2300 to 2500° F. The majority of the sensible heat in the waste gases is recovered in the regenerators, so that these gases leave the regenerators at about 480° F.

Producer Gas Plant

The producer installation consists of 10 Koppers-Kerperly producers. At the present time about 40,000,000 cubic feet of producer gas is being produced per 24 hours. Small coke of the nut and breeze size is used in these producers—about 30 tons per day per producer being required.

The producers are water jacketed, which serves three purposes; to produce low pressure steam which is blown under the grates with the blast; as a feed water heater for the waste heat boilers; and to eliminate side clinker in the producer.

Waste heat boilers are connected to each producer. These boilers produce steam at approximately 200 pounds pressure, and the volume of steam produced is sufficient to operate all the blowers and exhausters required in the producer gas operations, leaving some surplus for other purposes. The surplus steam amounts to approximately 4,000,000 pounds per month.

Fuel is charged into the producer without interrupting its operation, and in a like manner, ashes are discharged at the bottom of the producer so that its operation is continuous. The discharging of the ashes at the bottom of the producer is accomplished by means of a plow which extends into a water sealed revolving grate. The ashes are removed by means of small buggies operating on a narrow gauge track below the producers. These buggies discharge the ashes into a skip hoist at one end of the building, which discharges them into cars for disposal.

After the gas leaves the ovens it is passed through the primary condensers and tar extractors. It then passes into a saturater where it comes in contact with a weak solution of sulphuric acid. This sulphuric acid absorbs the ammonia from the gas and precipitates a salt which is known as ammonium sulphate, which is taken out of the saturater by means of an air ejector, and dried in centrifugal dryers. From the dryers the sulphate is stored in a large room where it can be shipped either in sacks or in bulk.

Water Gas Plant

The water gas installation consists of nine Western Gas water gas sets, each having a capacity of 3,500,000 cubic feet per 24 hours. Each set is equipped with a waste heat boiler which utilizes the heat in the blast gases from the machine. These boilers, which are of the fire tube type, produce enough steam at 200 pounds pressure to provide approximately 65% of the total steam required in the water gas operations.

Each machine is equipped with a steam turbo-driven centrifugal blower, which supplies the air required in water gas production. The flow of steam to the turbine driving each centrifugal fan is controlled by an arrangement connected to the automatic control, whereby the closing of the blast valve to the machine simultaneously shuts the steam off from the turbines.

All valves used in operating the water gas machines are hydraulically operated and their proper operations are controlled by an automatic machine. This automatic machine is really a timing device which operates the hydraulic controls to the

valves so that each valve operates in the proper sequence and at the proper time. The automatic can be adjusted to any schedule of valve operation desired. With these automatics it is possible to operate three machines with one attendant.

The steam required in producing gas in the water gas sets is furnished by the exhaust steam from all steam-using equipment in the plant. This is supplied to the set at approximately 4 lb. pressure, and a tie-in with a live steam line is arranged so that any shortage of exhaust steam can be made up by live steam.

The ashes and clinkers removed from the machine at regular intervals are dumped into a skip hoist, which elevates them to an overhead hopper adjacent to the boiler house, which also receives the ashes from the boilers.

Fuel Handling Equipment

The most modern equipment has been installed in the plant for handling fuels. Two thousand tons of coal per 24 hours are required for full operation, from which 1400 tons of coke are obtained. From the time the coal is unloaded from cars until the last stage of the water gas operation where coke is consumed, all coal and coke are handled by mechanical belt systems.

The coal is brought in in cars, is dumped into a track hopper, picked up by a belt conveyor and conveyed to Bradford breakers, where it is crushed to pass a 1½-inch screen. Any coal which is not crushed in the breakers, and any foreign material, falls on to another belt which carries it to an auxiliary station where it is crushed and the foreign material removed. The coal then passes, by means of a conveyor, to the hammer mill and mixing bins where it is pulverized and properly mixed.

In order to get the highest efficiency from the use of coke in the different trades, it is necessary to give particular attention to the preparation of the coal. For instance, the factory trade demands a large size, dense coke, with very low ash and sulphur content, while blast furnace and water gas plants obtain much better results with a more open and faster burning coke. These results are accomplished by crushing and pulverizing different coals to a uniform size, and then mixing two or three kinds together. The mixing plant is equipped to mix three kinds of coal, and the mixture is accurately controlled by the opening of hopper gates and the speed of the belts carrying the different coals to the mixing hopper. After being properly mixed, the mixture is conveyed to the storage bins above the ovens.

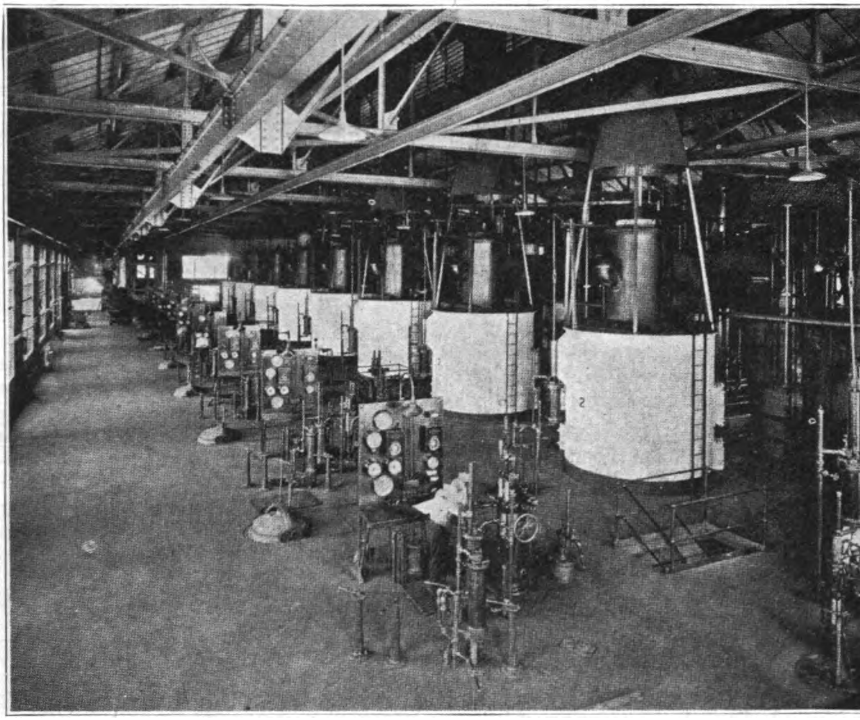
From these storage bins it is conveyed by means of a charging lary car running on top of the ovens, to be charged into the ovens.

Coke Quenching, Screening and Sampling

When the coke is taken from the ovens, it is pushed in the hot state into a specially designed railway car which delivers it to the quenching station, where water is sprayed on the hot coke to cool it. It is very important that only sufficient water be sprayed to cool the coke without allowing an excess amount of moisture to be retained. This is arranged for by a float in the quenching station which controls an electrically operated valve so that the operator merely pushes a button when the coke car is in position, and the water shuts off when the proper amount of water has been passed. This method has been very successful in keeping the coke at a uniform moisture content.

After quenching, the coke is dumped on to a coke wharf where it is allowed to cool further, and then dropped on to a traveling belt which conveys it to a screening station where the large size coke is separated. This larger size coke can either be loaded directly into cars for shipment, delivered to the water gas plant for use there, or delivered to storage piles.

An automatic coke sampler, operated by a solenoid, collects a small sample from the main conveyor at short intervals, so that all the human element is eliminated in obtaining a fair sample. This sample is of the utmost importance, as most of the coke is sold on an analysis guarantee. An additional station is provided, so that coke which is to be disposed of in the open market can be properly sized. Additional screening at this point gives five sizes—egg, stove, nut, pea, and breeze,—for domestic trade or producer operation.



OPERATING FLOOR OF WATER GAS PLANT SHOWING AUTOMATIC CONTROL IN FOREGROUND.

The coke required for water gas operation is taken from the main screening station by means of mechanical conveyers, and conveyed to storage bins above the operating floor of the water gas house, from whence it is taken by means of a lary car which charges the water gas machine with the proper amount of coke and at the same time weighs the amount of coke charged into each machine.

Wherever necessary, the mechanical conveyers are so interlocked that the stopping of any one in the series will stop all others in the same series ahead of that one. This prevents the clogging of any conveyer in case of breakdown.

Gas Purification

Both the water gas and coal gas must be purified, and this is accomplished by means of two sets of purifiers—eight boxes in each set. These purifying sets are built of concrete, partially under, ground, each box containing 20,000 bushels of oxide.

Boiler Plant

The boiler plant consists of four B. & W. boilers, each of 710 horsepower, arranged for firing with coke breeze. The supply of feed water is provided by the hot water from the condensers in the water gas plant. A water treatment plant is provided to assure the proper kind of water for boiler use. The disposal of the ashes is accomplished by means of a skip hoist which discharges into the same overhead hopper which receives ashes from the water gas plant.

The coke breeze is brought to the boiler house by railway cars which dump into a track hopper, from whence it is conveyed into bunkers over the boilers. This same track hopper can be used in case of emergency for taking water gas coke from cars and conveying it to the coke bins in the water gas house.

Most of the pumping equipment throughout the plant is of the centrifugal type. Practically all the pumping equipment is driven either by motors or turbines. All

water required in the plant is taken from the Drainage Canal, and to as large extent as possible, all water is recovered for re-use.

Controlling and Recording Apparatus

In a plant of this kind, where the control of heats is of primary importance in obtaining proper efficiencies, suitable measuring and recording apparatus must be used in order properly to control heats. Such apparatus is used to a large extent in both the coal gas and water gas operations. Wherever necessary, recording temperature charts are provided, flow meters are furnished for the measurement of steam, air, and gas, and pressure regulation is provided where necessary.

Proper operation of the ovens requires that the pressure regulation must be maintained within about 2 millimeters of water. This is accomplished by means of a Van Ackeren governor on the collecting main from the ovens. With this apparatus it is possible to maintain a constant pressure of approximately 3 millimeters of water on top of the ovens. This governor is so sensitive that there is not more than 1 millimeter variation either way from the standard.

Holders

Both the water gas and coal gas, after being properly treated to prepare it for distribution, is stored in a 10,000,000-cubic foot holder. Plans for this summer provide for the installation of another 10,000,000-cubic foot holder. The tank of this holder contains 16,000,000 gallons of water, and in the winter time it is necessary to prevent this water from freezing. This is accomplished by taking the hot water from the primary coolers and supplying it to the holder.

Distribution Station

In the distribution station, where the gas from the commercial holder is pumped into the distribution system, there are two centrifugal pumping units driven by electric motors. The larger of these two units has a capacity of 2,800,000 cubic feet per hour at 6½ pounds pressure. It is driven by 1750-horsepower, constant speed, synchronous motor. The current supplied is 2300 volts A. C., 60 cycle, 3 phase. The smaller unit has a capacity of 1,000,000 cubic feet per hour at 6½ pounds pressure. It is operated by 1350-horsepower, variable speed motor. The current is 440 volts, A. C., 60 cycle, 3 phase.

In both these units the blower operates at approximately 3600 r. p.m.

In addition to these two units, there are two 1,000,000-cubic-feet-per-hour units of the exhauster type. One of these is driven by a steam reciprocating engine, and the other by a gas engine. It is planned, during this year, to install at this station another electric driven centrifugal unit, having a capacity of 3,600,000 cubic feet per 24 hours.

Storage of Fuels and Materials

In a plant of this size it is necessary that every precaution be taken against interruption to service. In order to assure continuous operation, ample provisions have been made for the storage of materials and fuels necessary in the production of gas. It is possible to store 400,000 tons of fuel—either coal or coke—in the plant. Normal operations require that approximately 100,000 tons of bituminous coal be in stock at all times.

The large quantity of materials required to be handled throughout the plant, necessitates the use of either conveying apparatus or cars. The conveying apparatus has already been described, but in addition, there are three locomotives and four locomotive cranes.

A large machine shop, with a capable force of mechanics, is provided to do the necessary maintenance and repair work of the plant, so that practically any repair job can be accomplished within the plant.

TECHNICAL PAPERS

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Some Phases of the Illinois Central Railroad Company's Lake Front Improvements and Electrification

By D. J. Brumley,* M. W. S. E.

Presented March 10, 1925

THE terminal improvement work being undertaken by the Illinois Central Railroad Company in the city of Chicago might be better understood if a brief resume is made of incidents leading up to the entrance of this railroad into the city.

In 1850 the transportation facilities of the present great city on Lake Michigan were woefully inadequate. The several attempts made by the State of Illinois during the previous twenty years to create transportation lines such as—highways, canals and railroads—resulted in incurring an expenditure of ten or more million dollars but accomplished very little. The most successful of these efforts was that of the Illinois and Michigan Canal, extending from Chicago to La Salle, commenced in 1820 and completed in 1848. The canal served a limited area only; its capacity prevented the use of large and economically operated boats; frequent breaks in the masonry or failures in the locks made navigation difficult even during the summer months; and finally ice rendered the canal useless in the winter season. The only railroads in the State at this time were the Springfield and Meredosia Railroad between Springfield and Jacksonville and the Chicago & Galena Union Railroad (now a part of the C. & N. W. Railway System), the latter terminating about twenty miles from the business center of the city.

With conditions as they were at this time, the most important need of the State was some system of transportation which would connect the fertile interior counties with the great lakes and the Mississippi River. It was realized that transportation lines must be provided if the State were to develop and keep pace with the rapidly growing eastern States. The products from the great fertile plains in the central part of the State must find a market with adequate transportation the whole year round. Many schemes came before the people but the one which had the greatest possibilities and appealed most strongly to the good sense of the citizens was a central railroad extending from Galena or Dunleith on the Missisippie River to Cairo on the Ohio River. The people of the State were not disposed to acquiesce in a further increase in the State debt and repeat the costly and unfruitful attempts to construct transportation lines under State supervision but were willing to lend their encouragement to private capital undertaking such enterprises. The Illinois Central Railroad Company was willing to undertake the task.

It required more than a decade of discussion in Congress and the General Assembly of the State to bring about tangible results. To avoid sectional differences, Congress voted a land grant to the States of Illinois, Mississippi, and Alabama. The General Assembly of the State of Illinois granted a charter to the

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Illinois Central Railroad Company in 1851. These acts might have failed of passage had not Senator Stephen A. Douglas, an owner of land in Chicago at 36th Street and Lake Michigan, contributed his zeal and ability to the enterprise on condition that a branch should be built from Centralia to Chicago as well as the main trunk line from Dunleith to Cairo.

As an inducement, the grant of lands to the State of Illinois, being each alternate even numbered section within six miles of the located line of the Railroad was turned over to the Illinois Central Railroad Company on condition that the Railroad Company would build the railroad, aggregating 705 miles, within six years, and pay seven per cent of its gross earnings to the State of Illinois in lieu of all other taxes.

Lake Front Site Chosen

The promoters of the railroad were desirous of securing a location in the city of Chicago which would place the freight and passenger terminals convenient to the business district and also be in a location for easy and expeditious interchange with other railroads.

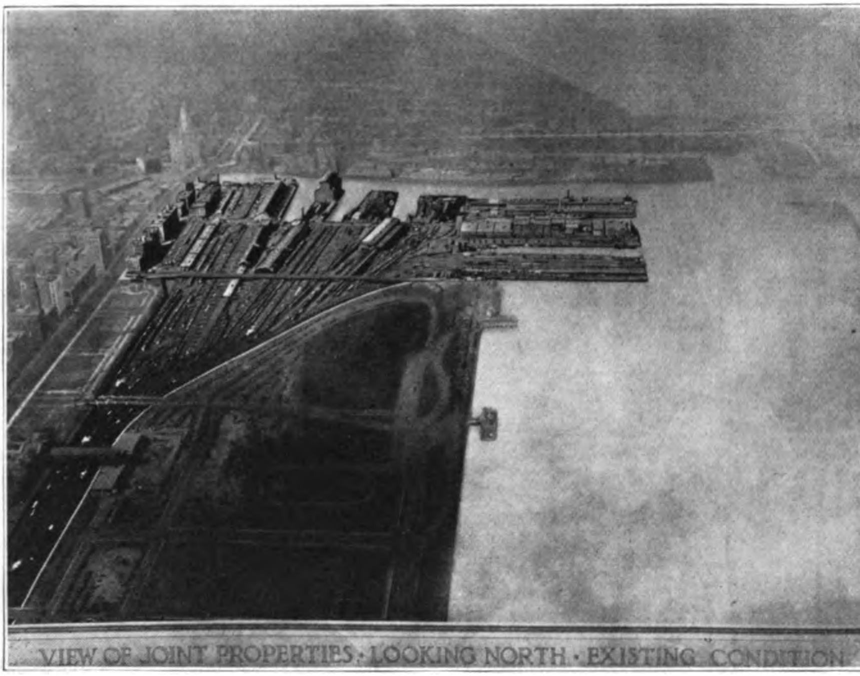
The line first surveyed lay along the south branch of the Chicago River from the then southerly limits to the central part of the city, and to a connection with the Chicago and Galena Union Railroad. The City Council declined to consider any location other than that the railroad should intersect the lake shore at the foot of present Fifty-first Street and occupy the lake front northward from that point to the Chicago River.

Seventy-five years ago Michigan Avenue was the aristocratic residence street of Chicago and the proposition to locate a steam railroad along the Avenue provoked strenuous opposition from the property owners who believed it would diminish the value of their investments. On the other hand the north and west wards had for years paid heavy taxes to protect the lake shore from the encroachments of Lake Michigan and that portion of Chicago gladly supported the lake front occupation plan. They argued that the city was poor and the assumption by the railroads of the expense of maintaining the protective levees on the front of the city would more than compensate for any depreciation of the value of residence property in the neighborhood. Mass meetings and parades were held by each side; circulars and petitions were widely circulated; the newspapers took an active interest in the matter; and both sides threatened to resort to legal proceedings to gain their point. The fight was conducted before the City Council for a period of more than six months and an ordinance was passed June 14, 1852. The ordinance carried with it a grant of a right of way three hundred feet wide through any public lands of the city, extending from Lake Park Place (11th Street) to Randolph Street. By interposing a railroad between the city and the lake it was argued that the railroad company would be obligated to operate the railroad and for its own protection would be compelled to maintain breakwaters, dykes, and other protective devices, thereby securing the city from the lake storms, and relieving it of very considerable expense. Even with the grant of lands, the railroad company reluctantly accepted the ordinance.

Limits Extended

As the city grew and the limits were extended southwardly from time to time the obligation of the railroad to maintain lake front protection was extended automatically. Finally the railroad company assumed the obligation of constructing and maintaining the lake front protection from the Chicago River to Fifty-first Street, a distance of approximately six and one-half miles.

In 1860 Chicago had a population of thirty thousand. It was then thought that the lake front would be of little, if any, value to the city. The Chicago River furnished water transportation for boats of limited draft. This waterway soon became overcrowded, and the increase in bridges over the stream forced water traffic to seek a water terminal not surrounded by such limitations. With the increasing population it became apparent that the city must make use of Lake Michigan for transportation, and the lake shore for recreational purposes. Accordingly Harbor District No. 1, east of the Chicago River, and the lake shore north thereof, was established July 28, 1913. Harbor District No. 2, extended from the southerly limits of District No. 1 to 16th



AIRPLANE VIEW OF PRESENT YARDS AT RANDOLPH ST.

Street was established April 2, 1916, and the Lake Front Ordinance of July 21, 1919, extended the harbor limits from Sixteenth to Thirty-first Streets, to be known as Harbor District No. 3.

The right of way between Randolph Street and East Eleventh Place consists of an easement in perpetuity granted by the City of Chicago. From East Eleventh Place south the Railroad Company acquired title in fee simple from individual owners to a right of way which vested in the railroad company the riparian rights attaching thereto. The right of the Railroad Company to use the accretions to the shore line or to fill it in was contested by the city. The differences of opinion which arose from time to time were not finally disposed of until the passage of the Lake Front Ordinance, July 21, 1919.

The development of Grant Park west of the Railroad between Randolph Street and East Eleventh Place was completed in 1895. At this time the Railroad Company lowered the plane of its tracks north of East Eleventh Place and constructed viaducts at Randolph, Monroe, Van Buren, Harrison and Eighth streets, thereby providing accesses from Grant Park on the west side of the railroad to the section of Grant Park being developed on the east side. Prior to 1893 an extensive area known as Jackson Park, the site of the World's Columbian Exposition, had been developed by the South Park Commissioners between Fifty-sixth and Sixty-seventh streets, extending from Stony Island Avenue east to the Lake. With Grant Park east of the railroad nearing completion and Jackson Park already well established, the Chicago Plan Commission and the South Park Commissioners became active in devising ways and means to connect these two park systems and have one continuously developed shore line from the north to the south limits of the city.

The demand for a continuous city playground along the entire lake front became so urgent that negotiations were entered into by the South Park Commissioners and the Railroad Company to fix an easterly boundary line of the lands of the Railroad Company between East 11th Place and 49th Street, and

thereby vest in the Commissioners right to reclaim park areas, construct park accesses across the Railroad Company's property, establish bathing beaches, and provide lagoons connecting Grant Park, opposite the central business district of the city, with Jackson Park on the south side. In 1912 the boundary line was established by an agreement between the Railroad Company and the South Park Commissioners. The Railroad Company relinquished to the South Park Commissioners its remaining riparian rights on the lake front, which had not theretofore been sacrificed by contract, ordinance, or otherwise. This agreement did not authorize either the Railroad Company or the Commissioners to fill in submerged lands until the approval and authority of the Secretary of War had been obtained. The Secretary of War refused the application made by the South Park Commissioners and the Railroad Company to fill in any of these submerged lands until the plans were approved by the City of Chicago and specific provision made for a southerly extension of the Harbor District then terminating at Sixteenth Street.

Lake Front Reclaimed

Previous to, and in anticipation of, the boundary line agreement with the South Park Commissioners, the Railroad Company consented to the location of the Field Museum of Natural History on lands which it had reclaimed, and thereby made possible, within the time specified by the donor, the dedication of this magnificant gift to the city of Chciago.

The so-called Lake Front Ordinance, of July 21, 1919, is, in fact, a three-party contract entered into by the City of Chicago, the South Park Commissioners, and the Illinois Central and Michigan Central railroad companies. It confirms the provisions of the contract of 1912 between the Railroad Company and the South Park Commissioners, provides the Harbor District demanded by the United States Government, and grants the right to fill in certain submerged areas, to establish driveways, lagoons, bathing beaches, and recreational centers, and to construct additional viaducts over the right of way and tracks of the Railroad Company between Randolph Street and East Roosevelt Road, and also at 23rd, 31st, and 35th streets, Oakwood Boulevard, and 43rd Street, and subways at 18th and 47th streets, thereby giving frequent, convenient, and adequate accesses, within reasonable construction cost, to the park areas, the Field Museum, the new Stadium, the proposed aquarium, and to the Harbor Districts. The Railroad Company will construct the harbor approaches at 18th Street (a subway) and viaducts at 23rd and 31st Streets. The Park approaches are to be built by and at the expense of the South Park Commissioners.

The South Park Commissioners are making good progress on the program to develope the shore line between Grant and Jackson Parks by building breakwaters, filling in the submerged lands, constructing viaducts and subways between the city and the park area, constructing driveways in the park area, establishing bathing beaches, playgrounds, etc.

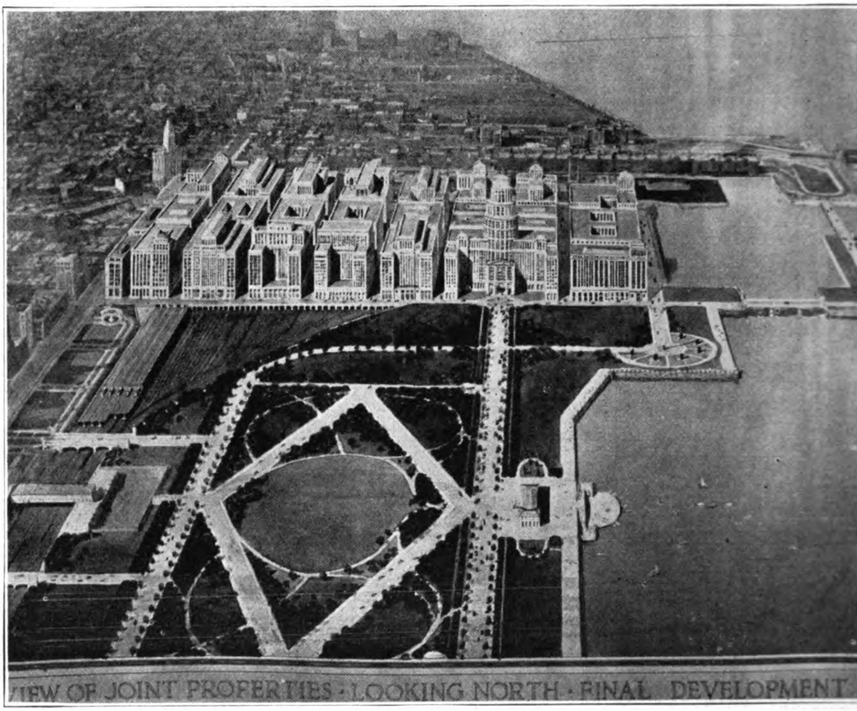
The Federal, State, and City authorities, the South Park Commissioners and the Railroad Company were vitally interested in the solution of the problem. It is needless to say that in an understanding of this magnitude there was no yielding on the part of any party. The future needs of the Federal Government had to be met; the comprehensive civic plans of the city were given due weight; the wish of the South Park Commissioners to restore Chicago's lake front playground to the people of the great west side was guaranteed realization in the approximately immediate future; and the needs of the Railroad for a more economically operated terminal are in process of fulfillment. The intimate partnership which the Railroad Company reluctantly accepted under the provision of the original ordinance of June 14, 1852, has been reaffirmed by the Lake Front Ordinance of 1919.

The following are the major projects which the Railroad Company will undertake to carry out under the provision of the Lake Front Ordinance:

1. Fill in and reclaim submerged lands in the South Water Street area and the lake shore between 16th and 49th Streets.

2. The reconstruction and enlargement of the suburban facilities.
3. The rearrangement and reconstruction of the local freight terminal at South Water Street, including the reconstruction of Randolph Street viaduct, 64 feet wide and 1725 feet long.
4. The relocation and reconstruction of the through passenger terminal and office building with appurtenant facilities, including the construction of a subway 100 feet wide and 680 feet long at the foot of 18th St.
5. The installation of substations and overhead transmission and distribution systems in preparation for electrical operation after the tracks, platforms, and other facilities have been rearranged.
6. The construction of additional tracks on the main line between the Chicago River and Matteson and also on the South Chicago, Blue Island, and Kensington branches.
7. The relocation of the easterly end of the St. Charles Air Line which interferes with the development of the through passenger terminal.
8. The construction of an elevated railroad between 18th and 20th Streets, making a separation of grades with other railroads, streets, avenues, alleys, and public places, extending from the Illinois Central main line south, and connecting with the Atchison, Topeka & Santa Fe, and the Illinois Central line west, in the vicinity of Archer Avenue and Canal Street. This railroad will make it possible for all north and south and western line railroads to make reasonable connections therewith for the purpose of reaching either Harbor District No. 3, or the Lake Front through passenger terminal.
9. The lowering of the plane of the tracks between 29th and 43rd streets to a minimum elevation of plus four, Chicago city datum, thereby permitting most economical construction of viaducts by the South Park Commissioners at 31st and 36th Streets, Oakwood Boulevard, and 43rd Street. The raising of the plane of the tracks between 43rd and 51st streets to permit of the construction of a subway by the South Park Commissioners at 47th Street. These changes of grade involved the rebuilding of the breakwater for the major part of the distance, filling in the submerged areas to be occupied immediately, lowering or raising the eight main and other supplemental tracks under traffic, reconstructing the retaining wall on the west side of the right of way, constructing additional tracks, reconstructing the signal system, relocating, diverting and lowering City sewers within the area affected, and installing protection at the Sanitary District's twenty-foot discharge outfall sewer under the tracks at 39th Street.
10. To change the method of propulsion from steam to electric as follows:
    The entire suburban service............ ....On or before Feb. 20, 1927
    The freight service north of E. Roosevelt Rd. ....On or before Feb. 20, 1930
    The freight service south of E. Roosevelt Rd. ....On or before Feb. 20, 1935
    The through passenger service........ On or before 1940 providing a given percentage of the railroads using the Lake Front Passenger Terminal are operating electrically at that time.
11. Construct the 18th Street Railroad, of not more than six main tracks, when and as its need is justified.
12. Constructing three railroad accesses to Harbor District No. 3; Harbor Approach viaducts at 23rd and 31st streets and a Harbor Approach Subway at 18th Street.
13. Permit other railroads entering Chicago to use the railroad accesses to Harbor District No. 3 and to use the Lake Front through passageway facilities either on terms mutually agreed upon or those established by the Interstate Commerce Commission.

The Illinois Central Railroad Company's suburban and local freight terminals east of Michigan Avenue and north of Randolph Street cover an area of sixty-five acres, the upper level of which is admirably adapted for the same type of commercial development as obtains in the central business district. The suburban service and local freight business can be



ARTIST'S CONCEPTION OF RANDOLPH TERMINAL DEVELOPMENT

adequately cared for below the level of Randolph Street viaduct and the volume above the viaduct level, with proper arrangement of east and west and north and south streets, is susceptible of the highest type of development authorized by the Chicago Zoning Ordinance.

The plans for suburban and local freight terminals provide for releasing this area for air right development in the immediate future. Vehicular accesses to the local freight terminal and the air right development will be separated. The accesses to the former will be along the lower level driveways on Lake, South Water, and River streets and those to the latter from the upper level of Michigan Avenue, and the connecting north and south streets.

A railroad terminal to serve best the purposes of a transportation machine must lie within easy and convenient reach of business centers and must provide adequate and uninterrupted means of transportation for suburban and through passenger service, and local freight business. In order that these three classes of business may be served adequately and without interference, they each should comprise separate and distinct units of the terminal development, have ample connections with other railroads for expeditious interchange, and suitable provision for adequate vehicular traffic accesses and local transportation connections.

The suburban passenger terminal lies east of Michigan Avenue along Beaubien Court, a north and south street, and extends from Randolph to South Water Street. Convenient stations to the central business district will be located at South Water Street, Randolph Street, Van Buren Street, and East Roosevelt Road. The entrance at South Water Street will be from the upper level streets, to Randolph and Van Buren Street stations it will be by means of subways from the west side of Michigan Avenue, and to East Roosevelt Road along the pedestrian approaches to the through passenger terminal.

The plans for suburban operation are pretty well settled. The Randolph St.

Terminal will first be constructed with eight station tracks of sufficient length to accommodate a train of ten cars of the new standard steel type. The operation of suburban trains on the main line south will be on tracks set aside exclusively for that service and the operation can be carried on without interference with that of the through passenger, freight or switching. From Randolph Street to East Roosevelt Road the operation will be confined to four main tracks; from East Roosevelt Road to Fifty-third Street six main tracks; from Fifty-third Street to Kensington four main tracks; and from Kensington to the southerly terminus of the electrified zone two main tracks. The South Chicago and Kensington & Eastern Railroads will each have two main tracks and the Blue Island Railroad one. The branch lines will, of course, handle both suburban and freight business.

Services Segregated

At East Roosevelt Road the suburban tracks will occupy a tunnel below the facilities of the through passenger terminal. The plan provides for the segregation of suburban service tracks and placing them on the westerly side of the right of way most convenient to the patrons of this service.

The right of way on the main line south is nowhere less than 200 feet wide. The plan for the final main track development of the right of way is as follows, the enumeration being from the west side; two industrial switching tracks, four suburban tracks; four through passenger tracks; and three freight tracks.

The through passenger station building will be south of and adjoining East Roosevelt Road — the principal east and west thoroughfare, 118 feet wide, extending from Grant Park west to the city limits—and a half block east of Michigan Avenue, the only existing through north and south boulevard. The station lands have a frontage of 693 feet on East Roosevelt Road, an average width of 640 feet, comprise an area of 102 acres and extend from 8th to 31st Streets, a distance of two and seven-eighths miles.

The station and office building will be opposite the southerly end of Grant Park. The group of structures planned for the civic ornamentation of this section of the lake shore development are nearing completion. The Field Museum of Natural History with which the station building will harmonize in texture, general architectural treatment, and color stands east of the railroad. The Stadium completed last year stands south of the Museum and the John G. Shedd Aquarium soon to be built will stand at the foot of East Roosevelt Road and the Lake. The Railroad Company's station and office building furnish the westerly member of the ornamental group long dreamed of by E. H. Bennett and Daniel H. Burnham.

A through passenger station on the Lake Front is in a completed part of the city. Flanked on the east and north sides by a park forever dedicated to the public, on the west by Michigan Avenue, and to the south extends the railroad company's thoroughfare of main tracks.

The through passenger terminal is served not only by Michigan Avenue and East Roosevelt Road, but will also have the through north and south driveways in Grant Park east of the railroad. The park driveways will connect with the boulevard and street systems along the entire easterly front of the city. The vehicular accesses to the station, therefore, will be principally on boulevards reserved exclusively for swift moving vehicles and the traffic to and from the through passenger terminal will not interfere with the operation of slow moving freight trucks. In point of time the station is nearer to the central business district than any of the other through passenger stations in the city. Travel to the far distant points of the city can be made on boulevards and thereby relieve the already congested heavy traffic streets.

The accesses to the baggage, mail, and express facilities will be on Indiana Avenue along the west side of the terminal. This street will be widened to 100 feet between East Roosevelt Road and Sixteenth Streets and will be the route of heavy traffic to east and west, and north and south streets.

The through passenger terminal in this location will, therefore, have adequate accesses by cabs and automobiles, will be close to existing surface and elevated lines, will have direct connection with

the railroad company's suburban service, and will be adjacent to the municipal subways when built.

This location of the through passenger terminal secures it from any interruption occasioned by the operation of suburban, freight, and switching trains. Being separated from the suburban terminal, the growth of the suburban business will in no wise affect the operation of the through passenger terminal. With the construction of the Eighteenth Street Railroad all railroads approaching the City of Chicago from the south and west will have convenient accesses to the Lake Front Station either by means of the main line from the south or the Eighteenth Street Railroad from the west.

The East Roosevelt Road viaduct is the northerly limit of viaduct construction and the Twenty-third Street viaduct the southerly limit, within the passenger terminal area. The elevations of subways and viaducts have been so fixed by the Lake Front Ordinance that it is possible to develop a passenger terminal with a total capacity of eighty tracks, none of which will be less than 1200 feet in length. If the growth of the Lake Front Passenger Terminal should demand, a through track arrangement can be constructed on the lowest level with two stub-track levels super-imposed, and all three levels have permissible gradients on the main track approaches.

In addition to the space required for the terminal station building there is adequate room for baggage, mail, express, and mechanical facilities of sufficient capacity to care for locomotives and through passenger equipment of all tenants using the terminal.

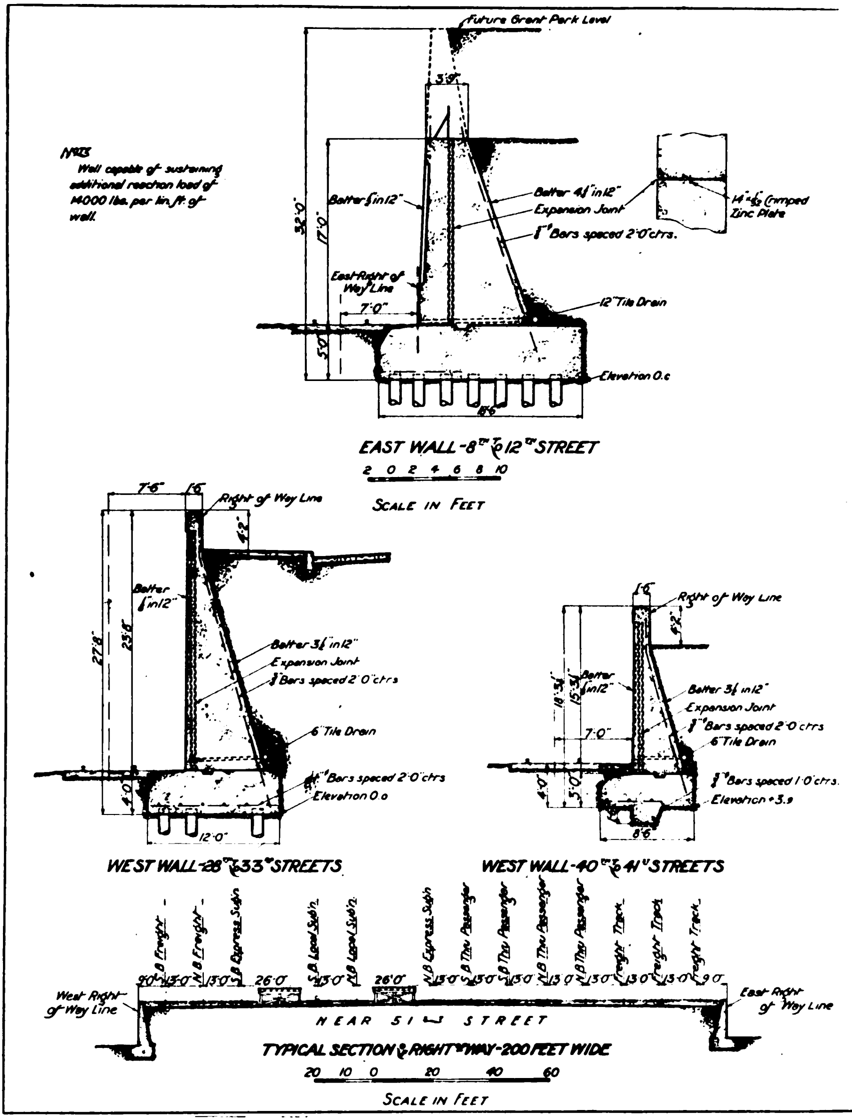
The location of the station is such, it is reasonable to expect the ultimate life of the terminal can be realized. In this section of the city the final plans for public improvements are being carried out by the civic authorities and the station owners may rest reasonably well assured of being able to write off the first cost at a low rate of amortization. It is clear, also, that the initial investment for creating a station of a given capacity in this location will be much less than any other as well favored location in the city.

In preparation for the electrification of all services, it was necessary to carry out many changes in tracks, relocation of intermediate stations and of overhead structures, separation of grades of railroads and to secure a final location for the tracks before the bridge supports carrying the electrical conductors are erected. This involves the completion of track elevation projects within the electrified zone, such as the track elevation between Eighty-third and One Hundred and Fifteenth Streets, Kensington; the grade separations of the Chicago Junction Railway at Forty-third Street; that of the South Chicago branch from the main line at Sixty-seventh Street; the separation of grades of the I. C. and Rock Island and C. & W. I. at Burnside; the separation of grades of the I. C. and C. & W. I. at Kensington; the grade separation of the I. C. and B. & O. C. T. and Pennsylvania Lines at Riverdale; track elevation at Harvey, and separation of grades of the I. C., B. & O. C. T. and Grand Trunk, and also track elevation in Matteson and separation of grades with the E. J. & E. and Michigan Central.

It was deemed uneconomical to attempt to continue the operation of Fordham and Wildwood Yards for handling the general classification freight to and from Chicago. To take the place of these two yards within the limits of the city of Chicago one known as Markham yard is now under construction at Harvey, a point twenty-two miles distant from the central business district.

Electric Propulsion Selected

The application of electric propulsion to steam railroad service, while used extensively in other sections of this country and abroad, is new to the city of Chicago. The Illinois Central problems are intimately associated with those of other lines in this city. To a certain degree, at least, the solving of our problems necessitated a measure of consideration to the interchange with other lines as well as adequately to care for this Company's own operation. Since the Smoke Abatement Commission's report was issued in 1915 there have been many advances in the art of electrification, and while this study had considerable value, it could not be adopted as a guide in determining the system of electrification for the electrification of the Illinois Central Railroad Company's Chicago Terminal.



RETAINING WALLS AND TYPICAL SECTION OF RIGHT OF WAY

On account of the nature of the problem it was deemed wise to make the investigation for a decision in this case the most thorough of its kind. To secure this result a Commission consisting of the ranking officer of the Illinois Central Chicago Terminal Improvement organization as chairman, three eminent electrical engineers experienced and skilled in the study and solution of electrification problems, and a staff of engineers, designers, and statisticians was created. The Commission was assigned the problem of reporting upon the electrification of the Chicago Terminal Improvements of the Illinois Central Railroad Company in accordance with the provisions of the Lake Front Ordinance of July 21, 1919.

The Commission considered the following systems:

1. Alternating current, 3-phase, with double catenary trolley.
2. Storage battery locomotive.
3. Diessel engine locomotive, or some other form of self-contained unit to meet the ordinance requirements as to emission of smoke, steam, cinders, or noxious gases and noises more objectionable than those produced by steam operation.
4. 750-volt direct current, third-rail.
5. 1500-volt direct current overhead catenary trolley.
6. 3000-volt direct current overhead catenary trolley.
7. 11,000-volt alternating current, single phase, overhead catenary trolley.

A study of the installation and operation of these systems resulted in the elimination of all except the 1500-volt direct current overhead catenary trolley and the 11,000-volt alternating current single-phase overhead catenary trolley. A comparison of the initial cost, maintenance, and operating costs and other advantages and disadvantages of these two systems included the study of:

1.—Power Supply

The direct current system was more favorable on account of the advantages of three phase power of either twenty-five or sixty cycles.

2.—Power Transmission

The three-phase unity power factor system had an advantage over the single phase low power factor system and this was considered an important element in the problem under consideration.

3.—Substations

The 1500-volt system required the installation of rotative apparatus in addition to static transformers. The alternating current system requiring only static transformers had a decided advantage in this respect.

4.—Distribution

With higher voltages the alternating current system had some advantage in first cost and in collection of current.

5.—Train Equipment

The direct current train equipments offered were materially lighter and cheaper than those for alternating current. In this respect the advantages were much in favor of the direct current system.

6—Inductive Interference:

This factor was present in consideration of the 11,000-volt alternating current system. While it was thought such interference could be mitigated, it involved additional cost of installation and some complication to electric traction installations.

7.—Electrolysis

Electrolytic corrosion can probably be mitigated or eliminated with less cost than to overcome inductive interference.

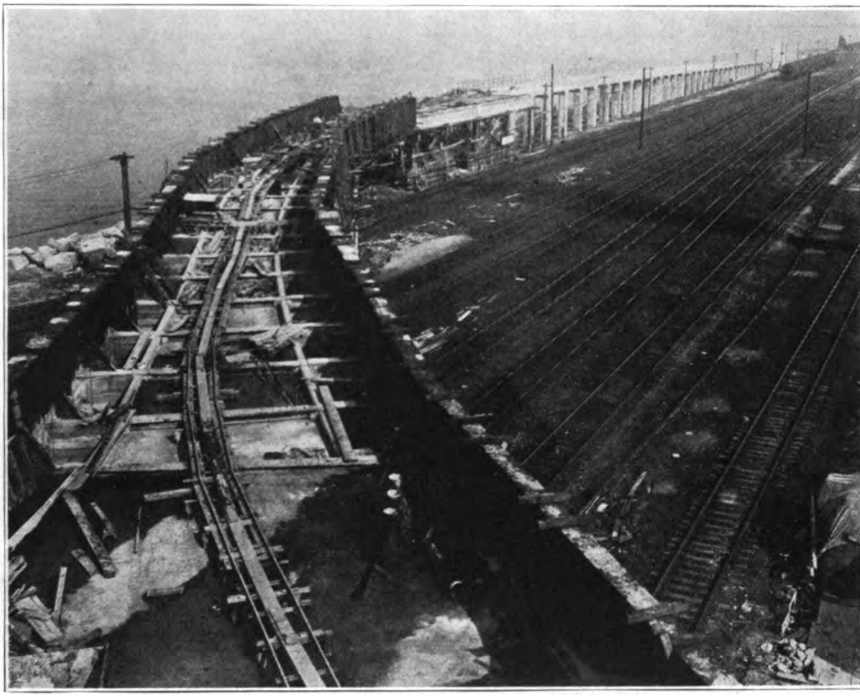
8.—Safety and Reliability

As regards the safety and reliability of the 1500 and 11,000-volt systems it was believed there was not a material difference, as both systems were thought to be adequate.

The Commission concluded from the result of the analyses and studies made that the 1500-volt direct current overhead contact system was best adapted for the operation of the Illinois Central Railroad Company's Chicago Terminal. This recommendation was adopted by the Railroad Company and this is the system now in process of installation.

One of the major electrification problems settled was that of obtaining power. Consideration was given to the generation and distribution of current from generating and converting stations to be installed, and operated by the Railroad Company and to the purchase of power from the Commonwealth Edison Company of Chicago. The traction supply will be direct current at 1500 volts, and miscellaneous light and power will be three-phase, alternating current at a nominal voltage of 4,000 volts between the phases and at a nominal voltage of 2300 volts from each phase to terminal.

As to the purchase of power, consideration was given to obtaining suitable high voltage alternating current from the Commonwealth Edison Company to be delivered to substations owned and operated by the Railroad Company and also to the purchase of direct current for traction and alternating current at such voltage and frequency characteristics as were required on the Railroad Company's distribution lines at substations to be owned and operated by the Edison Company. After consideration of the advantages and disadvantages of each scheme it was decided to purchase current from



OVERHEAD CROSSING AND APPROACH TRACKS NEAR 41ST STREET

the Commonwealth Edison Company, the power company to own and operate the substations and deliver traction current at 1500 volts and miscellaneous power at 4,000 and 2300 volts.

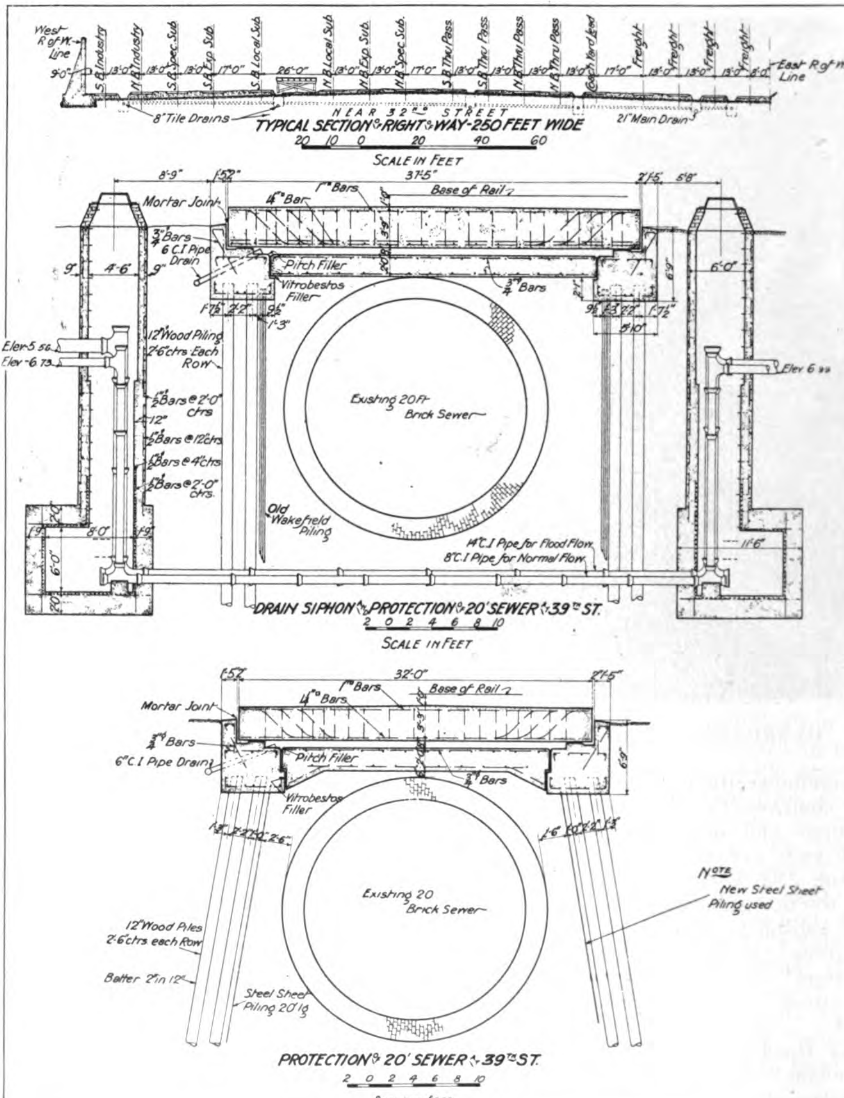
The traction substations to be installed by the Edison Company will be at:

18th Street	three	3,000-kw. Units
69th Street	three	3,000-kw. Units
115th Street	two	3,000-kw. Units
Harvey	two	3,000-kw. Units
Vollmer Road	two	1,500-kw. Units
Cheltenham	two	1,500-kw. Units
Blue Island	one	1,500-kw. Units

Such additional substations will be installed by the Edison Company for the distribution of alternating current for miscellaneous light and power at such other locations as are required for the proper distribution of power in connection with the operation of the electrified zone.

It was estimated that the initial load for suburban operation will require an hourly maximum demand of 22,000 kw. at the substations and for this operation alone approximately fifty-five million kw.-hours per annum.

The overhead system will consist of steel supports spaced approximately 300 feet centers for carrying the contact wires, signal and miscellaneous power circuits. The overhead contact wires will be supported by messengers of high conductivity, so that over each track there will be sufficient conductor capacity to supply the power required for that track, thus avoiding the necessity for independent parallel feeders. The contact wires, messengers, and their attachments will be made of materials highly resistive to corrosion. The normal height of the contact wire above top of rail will be twenty-two feet, and it will be suspended from the messenger so as to make its alignment conform to that of the track it serves. As the electrification will be carried out in progressive steps, the spans constructed initially for the suburban electrification will be extended ultimately to include the freight, through-passenger, and such subsidiary tracks as will be electrified. The track rails being well bonded will form a return circuit for the propulsion current and will be cross-bonded



A SEWER UNDER A SEWER. DRAIN SIPHON AND BRIDGE FOR PROTECTION OF SEWER AT 39TH STREET

at alternate impedance bond locations. The signal system is to be changed from direct current to alternating current to avoid interference with the signals from the direct current traction current in the rails.

Where only a double track is electrified the supporting structure will consist of an intermediate column spaced midway between track centers. These columns will be provided with brackets supporting the trolley system over each of the adjoining tracks. Where more than two tracks are to be electrified the support will be of portal-type bridge construction, the cross spans being of such length as to result in economical construction.

Forty-five steel suburban passenger cars have been purchased for the electrified service, but are temporarily used

in steam suburban service. The remaining cars, 215, are now on order, the delivery being specified for March 1926, in time to have them thoroughly tested out and ready for operation about the middle of next year.

A unit will consist of two cars semi-permanently connected, one being a motor car and one a trailer car. These units will have control apparatus in either end and will operate either as a two-unit train or multiples of two, probably not exceeding five two-car units.

The cars will be equipped with diaphragms, enabling passengers to move between cars at will, and thus make the most advantageous use of all the seats on the train.

Partly due to the use of aluminum and aluminum alloys and partly to a redesign of the original steel service suburban car, the weight of the motor car with equipment for electrical operation will be 125,000 lb. and the weight of the trailer 84,000 lb.

The braking equipment will be electro-pneumatic, the brake being designed for multiple unit service with the 1500-volt motor-driven compressor. Power for the control and brake operation as well as for the car lights will be furnished by a motor generator set on the motor car, having a 1500-volt direct current motor and a 32-volt direct current generator, with storage battery provided as a reserve. The two-car unit will have a pantograph collector on the motor car only.

Several types of electric heaters are under consideration, but it is not yet decided whether use will be made of open coil or strip heaters.

The general dimension data applying to the steel cars purchased and now on order are as follows:

Length over buffers	72 ft.	7½ in.
Length inside body	59 ft.	8¾ in.
Length of vestibule	4 ft.	
Truck centers	47 ft.	9 in.
Width over eaves	9 ft.	11½ in.
Width over platforms	10 ft.	6 in.
Width inside body	9 ft.	1 in.
Height, top of rail to top of car	13 ft.	5/16 in.
Height to center line of coupler	2 ft.	10½ in.
Height inside car to lower deck	7 ft.	13/16 in.
Height inside car to clerestory	8 ft.	4⅛ in.
Weight of present cars, light	92,200 lb.	
Seats, cross-seats	34, 68 passengers	
Seats, longitudinal	4, 16 passengers	
Windows	42 main windows	

The service provides for a high rate of acceleration and deceleration with a normal balancing speed of fifty-seven miles per hour on a tangent level track.

The motor equipment on each motor car will consist of four 750-volt, 250-horsepower motors connected in two groups of two motors in series per group with series parallel control.

A comparison of the present suburban steam schedules with proposed electric schedules in 1927 is illustrated:

To or From Randolph Street	Length of Trip Miles	Steam Operation: No. Intermediate Stops	Steam Operation: Schedule Time Minutes	Electric Operation: No. Intermediate Stops	Electric Operation: Schedule Time Minutes	Per Cent Decrease in Schedule Time Electric vs. Steam.
67th Street	**8.00**					
Local		14	30.0	14	24.5	18.3
Express		5	22.0	7	18.0	18.2
Matteson	**27.93**					
Local		34	85.0	34	71.0	16.5
Express		25	80.0	27	64.0	20.0
Special		13	67.0	13	50.5	24.6
Golf		10	59.0	10	46.5	21.2
So. Chicago	**12.47**					
Local		22	47.0	22	38.0	19.1
Express		13	38.0	15	31.5	17.1
Special		9	36.0	10	26.5	26.4

Work Accomplished to Date:

The excavation under Grant Park south of Randolph Street and retaining wall north of East Roosevelt Road on east side of right of way.

Randolph Street Subway.

Van Buren Street Subway.

Filling submerged lands, being three slips on the Chicago River and two on the lake at South Water Street, and also the submerged lands along the shore line between 16th and 33rd Streets.

Construction of retaining wall on the west right of way line, 29th to 33rd Street, and 40th to 41st Streets.

Lowering the grade, rearranging tracks, and construction of additional tracks 29th to 43rd Streets.

Raising grade, rearranging tracks and constructing additional tracks, 43rd to 51st Street.

Subsurface drainage between 29th and 39th Streets, where the established grade line is at elevation plus four, Chicago city datum.

Construction of sewers in Rhodes Avenue between 35th and 39th Streets, to take the place of the sewers formerly existing on the Railroad Company's right of way between these limits.

Protecting Sanitary District's 39th Street twenty-foot western outfall sewer.

Passenger subway at 43rd Street.

Extension of existing street subways between 70th and 115th Streets.

Grade separation with the Pennsylvania and B. & O. C. T. at Riverdale. This was begun in 1924 and is now practically fifty per cent completed.

Grade separation with the B. & O. C. T. and Grand Trunk, and track elevation at Harvey. This was begun in 1923 and will be completed in 1925.

Completion of Markham Yard in time for initial operation in October, 1925.

Construction of two additional tracks and extension of subways between Homewood and Matteson.

Track elevation at Matteson, including the separation of grades with the Michigan Central and E. J. & E.

Rearrangement of tracks and construction of platforms on the South Chicago Railroad, about sixty percent completed—the remainder to be done in 1925.

Placing concrete foundations for overhead catenary supports, South Chicago Railroad and main line south, near the southerly terminus of the suburban service. This work will be completed in 1925.

Purchase of copper for the distribution system and steel for the overhead catenary support system.

DISCUSSION

E. H. Lee: It has been a pleasure and a privilege to listen to this able paper. When I hear a speaker talk I like to know something about him. It's always useful. I like to know what kind of company he keeps. Our speaker tonight is working for one of the four or five greatest railroad companies in the country. He is working for a company whose chief executive is among the leading railroad men of the country and who has known how to surround himself with a personnel and an organization which can only attract the admiration and respect of all who come in contact with its members.

We none of us would care to admit that we are like the man who was on the witness stand in a law suit. The opposing counsel suspected that he knew some of the jury and asked "Do you know any of the jury here present?" The witness answered: "I may know one or two." "Do you know three?" "Yes." "Do you know half of them?" "Well, since you ask, I think I know more than the whole jury put together."

Without claiming to know more than others I can see that there is in some respects a quite radical difference in viewpoint between me and my old time friend, the speaker of the evening, and this difference refers particularly to the question of whether it is best for all interests, the railroads and the public, that the three groups of railroads known as the B. & O., La Salle and Dearborn Sta-

tion groups, handle their through passenger business in the proposed Illinois Central 12th Street Station, or whether it will be best for the public and these three groups to provide a passenger station on property which they now control in the general vicinity of the stations which they now occupy. If we argue the point we might be like the two knights who came up, one on each side of a shield hanging before an inn. One side of the shield was painted red and the other side black. Naturally one knight maintained that the shield was red, the other that it was black, and thereupon they rapidly proceeded from personalities to a fight. However, it will be different here. This is neither the time nor place for an argument on the merits of the big question, and there is always room for an honest difference of opinion. Most such differences are composed by a painstaking and systematic development of the facts. The paper of this evening covers a project that in some of its aspects is deserving of the greatest praise. When it comes to the question of the location of through passenger terminals, I contend that the shield is red. The speaker feels that it is black. We will have no argument as to that. I do maintain, however, that this terminal question is one of the most important that still remains to be solved in this city, and primarily it is not solely a railroad question. It is a civic and public question. I thoroughly believe that the interests of the public and of the railroads run along parallel lines; that what is best for the public is best for the railroads, and that what is primarily for the best interest of the railroads collectively, will be for the best interest of the public.

This terminal question is a very large and exceedingly complicated one. That portion of it that still remains to be settled, involving just what will be done in the way of terminal improvements for the three groups of railroads located west of State Street, is the greatest terminal question that has ever come up in this or any other city. It is a curious fact that a great many of the railroad terminal problems of the country have been dealt with and settled without a sufficient development of all the facts. Full and accurate information must be the basis for the wise settlement of any great question, and without arrogating anything to the group of men with whom I am associated, still less without assuming anything personally, it may be said that the investigation into this terminal question in the interest of the three groups referred to, which has been in progress for nearly a year, has been most thorough and painstaking. Few if any terminal situations have received anything like the same thorough analysis that has been given to this one so far by the men working in the interest of the three groups and the study is not yet completed.

What I want to say is that we are going through with the investigation. Your interests as citizens of Chicago, the interests of all the citizens of the city are at stake here. We believe that a right, proper and economical solution of this great terminal question is just as important for the people as for the railroads and *per contra,* that its wise solution can only be developed upon the basis of as full and accurate information as can be obtained and thoroughly analyzed, so as to furnish the basis for a correct decision.

All we ask is that judgment be suspended until the facts are dug up, classified and arranged in an orderly manner. Both sides of the shield may be red. If the facts disclose that we have been to some extent color blind and that the shield is black, I think that the situation when fully developed will make this clear.

R. F. Schuchardt: It is a little bit early to be saying anything from our viewpoint on this electrification. However, we feel that the Illinois Central used very good judgment in arranging for the purchase of their power.

It may be interesting to say something about the choice of system. With his usual foresight, Mr. Insull some years ago appointed a committee of his various companies to study railroad electrification, so that when the time came to supply power to the electrified steam roads of Chicago and vicinity, his engineers would understand in a measure, at least, what railroad problems are and what the railroad man requires in the way of

power and service. That committee had representatives from the Edison Company, Public Service Co., Middle West Utilities Co. and from the North Shore Road. You see, we had traction engineers on the committee also. Mr. Budd, President of the Public Service Company, was Chairman of that Committee. We studied railroad electrification from all possible angles and had experts come and tell us as much as we could absorb. Then we visited all of the steam railroad electrifications in America. We saw the terminal electrification in New York, the Norfolk and Western in the eastern mountains, in Philadelphia, and went to the Northwest mountains, where we saw the St. Paul road's electrification and the Canadian terminal installation of the. Great Northern. We came back and discussed the subject some more. We had learned a great deal about railroad requirements. We naturally came to some conclusions as to what we thought would be the best scheme to be applied here in Chicago. The so-called battle of the systems, which was exceedingly acute in the early days of railroad electrification, has now almost entirely subsided and the advocates of the several schemes have appreciated there was some good in each. Naturally we did not express our judgment in view of the coming negotiations with the Illinois Central Company, but we were, of course, very much interested in their studies and watched with a great deal of interest for the day when they were ready to announce their conclusions.

To make a long story short, we were happy, to find that our judgment was corroborated by the decision of the Illinois Central engineers with reference to the system they selected, and of course we feel they showed equally good judgment in their arrangements for power, including those with respect to the operation of the sub-stations. They appreciated that fundamentally the electricity supply companies should supply the electricity in the form that the transportation companies, whose business is transportation, can use. In other words, we transform for their use and do not supply at the generating station or transmission voltage which would have required that the railroad company do the transforming and converting to get the energy in the form needed.

E. J. Fowler: A word might be said about the power supply. The North end of the Illinois Central system would naturally be supplied from the Fisk, Quarry and Crawford power houses, which are just a short distance away. The 22nd Street and central part of the southern portion of the system naturally would be supplied from Calumet Station, which is perhaps 1½ miles east of 96th Street and the southern end of the system would be supplied either from the Calumet Station or from the Joliet Station of the Public Service Company of Northern Illinois, over the new 132,000-volt steel-tower transmission line which crosses the Illinois Central right of way. The load referred to by Mr. Brumley, 22,000 kilowatts, compares with the capacity of one unit just ordered for the Crawford Station of 75,000 kilowatts, or the one unit would be enough to supply three roads similar in size to the present Illinois Central electrification project. I mention this fact to indicate that no one road by itself could furnish its own power supply and have a diversity of supply that is possible from the power company. On acccount of the enormous size of units today and many other facts, they could not compare in cost of production.

Another factor is the substation. A very definite and important economy results in the power company building, owning, and operating the substations. The Edison Company has, as I remember upwards of 90 substations located throughout the city. The Illinois Central plans provide for 7 substations. Possibly some of those will be used both for Illinois Central supply and for the supply of our general light and power business.

In the development of electrification as it may proceed, and as we all expect it will proceed throughout the city some time, there will therefore be very definite economy in the number of substations if they are supplied by the power company rather than each road building it's own substations.

Another factor that I would like to mention—the Illinois Central of course, is one of the great coal carrying roads of the state. The Commonwealth Edison Company is one of the largest con-

sumers, using last year (1924) just a little less than 3,000,000 tons of coal.

Mr. Schuchardt: Mr. Brumley's committee made a much more thorough study of the problem, so his conclusions would be very much more complete. But some of the high spots were these: the ideal traction motor is the direct current motor. The use of alternating current motors is justified only because of advantages of alternating current transmission. But they require a 25-cycle or lower frequency. An A. C. system of more than one phase is too complicated to be practical, especially for switch tracks, so it gets down to a single phase system. A single phase system is first class, as far as the trolley goes, but 25 cycle is now an odd frequency. It means either a loss through frequency changes or the addition of 25 cycle generators, which is uneconomical, because you don't get the full benefit of diversity between the general business and railroad business. Weighing all of the advantages and disadvantages our committee concluded that the direct current system for this kind of railroad service was the best that the developments to date afforded. Mr. Brumley, thought the same. I don't think Mr. Brumley heard before this evening that that was the conclusion of our committee. We certainly did not know his committee was concluding thus, but hoped very much that they would.

Carrier Current Telephony on Power Transmission Lines

By N. H. Slaughter*

Presented April 6, 1925

Telephoning over transmission lines carrying high-voltage currents is the interesting process here described. Needless to say this innovation, which is the result of many years of effort, brings interesting possibilities to the power engineer who must have constant communication with all parts of the system to operate it at its best efficiency. Safeguards have been developed to limit the hazards to operators.—Editor.

THE rapid spread of power transmission lines throughout the country has made the telephone system used to connect the various generating and distributing stations of ever increasing importance.

When power transmission lines first began to be employed communication needs were generally taken care of by telephone lines installed by the power companies along their rights of way, or by the use of the regular commercial telephone service. Today high frequency telephony has added another means which may be used for this purpose.

Telephone lines installed along the rights of way of the power companies for the control of their power transmission systems are subject to certain limitations because of their close proximity to the power line. In times of storm the need for telephone communication is the greatest because it is then that trouble on the power transmission line renders the need of information between the load dispatcher and the various generating and distributing points even more acute than at ordinary times. It is at this time when the need is the greatest that the telephone line associated with the power line is most likely to be in trouble.

The development of the power line carrier telephone system now offers a highly reliable and satisfactory means of communication in connection with the operation of power systems. This equipment has been designed to employ the power connectors as the transmission medium and to provide service similar in reliability to the power lines themselves

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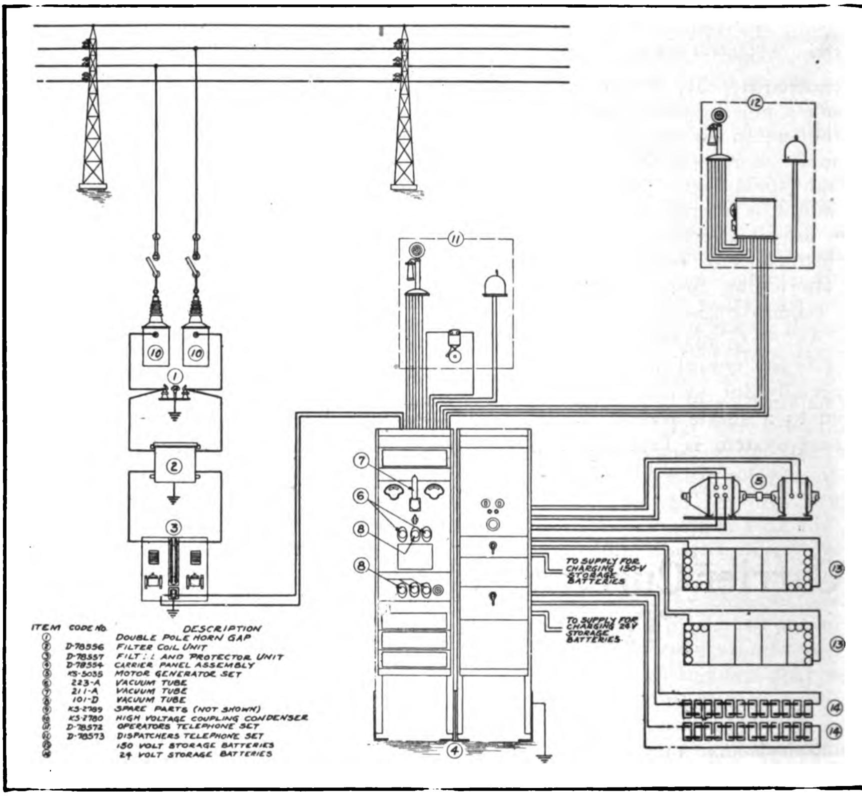


FIG. 1. DIAGRAM OF CONNECTIONS OF A COMPLETE CARRIER TELEPHONE TERMINAL.

with a low initial cost, a small maintenance charge, increased safety for the operating personnel and transmission comparable in quality and freedom from noise with that obtained on high grade commercial toll circuits.

In regard to the general scheme employed in this carrier system over power transmission lines, it is obvious that where there are associated together on the power transmission line the extremely feeble telephone currents and the extremely powerful power currents, some means must be provided whereby these currents can be separated from one another at the terminals and this separation must be of a very critical degree. For example, the power which is represented in the carrier telephone signal as it is taken from the power transmission line would ordinarily not exceed 1/1000 of 1 watt, whereas the power which is being transmitted at 60 cycles may be of the order of millions of watts, representing a ratio of a billion-to-one between the power and telephone currents. It is perfectly obvious that some means must be available which will be very critical in its selection of the power line carrier current as compared with its rejection of the power current.

The fundamental scheme is to generate a carrier frequency current which is of a relatively high order of frequency, for example, of the order of 100,000 cycles. This 100,000 cycle current is then modulated by suitable apparatus, in accordance with the speech wave forms or the currents which are transmitted over the telephone line. These modulated carrier currents having frequencies of the order of 100,000 cycles are then transferred to the power transmission line, by means which will be described short-

ly. They then travel over the power transmission line in company with the power currents, are taken from the line at the other end, amplified by vacuum tube amplifiers, and then they are demodulated in the same way a detector works in a radio receiving set. Then they become apparent again as speech in the telephone receiver.

One of the problems involved in the power line carrier system may be mentioned at this point — the most difficult problem — and one which has been only partially solved at present; that is, means of coupling the carrier equipment to the power line. It is perfectly obvious that the power transmission line must be treated with a great deal of respect, carrying as it does voltages as high as 220,000 volts in some cases. The connection between that line and the carrier equipment, which is a piece of very modest telephone apparatus, must be such that the equipment is completely insulated from the power transmission line, insofar as power frequency currents are concerned, but at the same time is efficiently connected thereto insofar as carrier frequencies are concerned. This constitutes the chief problem which has been encountered in the development of carrier telephone systems for power lines.

The first method which has been employed is the use of so-called antennae or coupling wires, which by virtue of the capacity between these conductors and the power transmission line conductors, along which they are strung parallel, form the connecting medium. High frequency currents will travel readily through a condenser or capacity and low frequency currents will travel less readily, and the relative readiness with which these currents travel will vary inversely as their frequency, so that in using currents of 100,000 cycles for the carrier and currents of 60 cycles or thereabouts for the power, there is a ratio, a very large ratio, favoring the transmission (through the capacity between this coupling wire and the power conductor) of the carrier currents.

FIG. 2. VIEW OF THE CARRIER PANEL AS INSTALLED.

More recently there has been developed a substitute for this rather awkward and inefficient coupling wire scheme in the form of fixed condensers. The development of these condensers has been a difficult problem, but it would appear that satisfactory types have been made available. They are rather heavy and rather expensive items of equipment.

Other methods of coupling to the line have been considered from the theoretical standpoint, such as transformers bridged

right across the line, the same way as power transformers, but such transformers would be so expensive, so difficult to build, that it has not been considered advisable even to put any of the theoretical ideas into practical form. It seems entirely unlikely that there will be any development along that line.

In connection with the transmission of speech over the line there is the problem which always occurs in any two-way telephone circuit, of separating the outgoing from the incoming currents. If station A is talking to station B, it is desirable that at the same time station A be in a position to receive from station B without the manipulation of any apparatus requiring a change in circuit. Hence, the problem of separating the outgoing transmission from the incoming; and since the relative order of magnitude of the outgoing and incoming currents is of the order of at least 1000 to 1, the problem is rather difficult.

In one type of carrier system which has been developed the means which are employed for separating the outgoing from incoming currents are selective circuits, which discriminate by virtue of their difference in frequency against currents of one frequency and favor currents of other frequencies. In order, then, to separate the outgoing from incoming currents different carrier frequencies are employed. Station A will transmit on one frequency and Station B will transmit on another frequency, and by the use of selective circuits or filters properly designed for the particular frequencies that are used, the outgoing currents will be excluded from the incoming circuit.

As an illustration of the difficulties which have been overcome in the design of selective circuits for power line carrier, some of the filters which are employed in commercial apparatus have a power discrimination ratio in favor of the desired frequencies as against the undesired frequencies of more than 1,000,000,000 to 1. That is, currents of the desired frequencies will enter with a power efficiency at least 1,000,000,000 times that of the undesired currents. This is accomplished in a piece of apparatus of modest dimensions and cost.

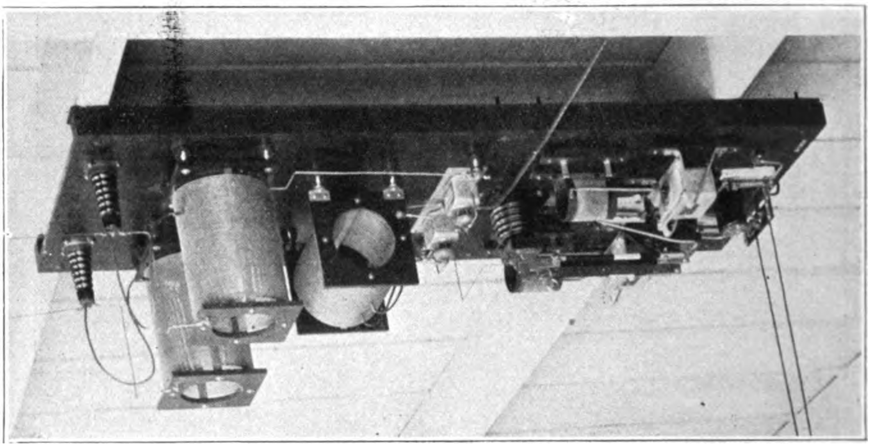


FIG. 3. PROTECTIVE EQUIPMENT WHICH IS SUSPENDED FROM THE CEILING ABOVE THE PANEL.

As to the facilities which are provided, power line carrier systems in commercial operation today are affording telephone circuits of high quality and comparative freedom from noise, with selective automatic ringing of any one of a number of desired stations, and suitable for use with extension lines. These extensions may run from the substation where the carrier equipment is located by means of cable or other extension circuits miles away to city offices or other points where the telephone extension service is desired. This service is afforded with a very high degree of safety. There have been no fatalities or anything approaching a fatality in con-

nection with any telephone circuits which are afforded by the carrier method. A great many tests have been made in which the coupling wires which form the connecting medium between the carrier equipment and the power transmission line have been deliberately connected to the power transmission line conductors, thereby putting the full power voltage on the carrier equipment, and in no case has any damage been done, either to the users or to the equipment itself. Means are provided which assure as close to absolute safety as it is possible to provide.

Among the problems which remain to be solved in the further improvement and perfection of carrier equipment are, first, improved methods of connecting the equipment to the line. Coupling condensers are efficient but are unduly expensive. Coupling wires are inexpensive but unduly inefficient, so that considerable work remains to be done in the improvement of means for connecting the equipment to the power transmission line. It seems altogether likely, in so far as the problem is viewed at the present time, that this improvement will lie along the line of better condensers, but of course revolutionary discoveries may be made which will result in the use of some other scheme which will be moderate in cost and high in efficiency.

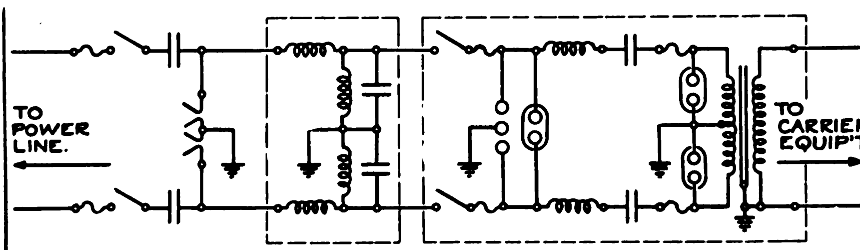


FIG. 4. DIAGRAM OF CONNECTIONS OF PROTECTIVE EQUIPMENT.

A rather interesting development which has taken place recently in connection with the use of carrier systems on power lines has been consideration of the use of special conductors carried on the power transmission line towers, not used for power transmission, but provided especially as a medium for the power line carrier equipment. The argument for this lies chiefly in the elimination of the coupling devices.

There are certain difficulties encountered in transmitting carrier over power transmission lines. It is customary in many power transmission line to sectionalize the line by means of disconnect switches; in cases of trouble, a certain section of the line will be isolated so that men can work on it, making repairs to insulators, broken conductors, or whatever may be the cause of the trouble. It is obvious that when using the power transmission line as the transmission medium for the telephone currents, that the interruption of that circuit will place an obstacle in the path of carrier currents. It can be stated at the present time in the light of information gathered in the past few years, that a single circuit power transmission line which is subject to breaks due to disconnect switches being opened is not a suitable medium for carrier currents, although a great many statements have been made which experience has shown have been unduly optimistic in that respect. Carrier currents do not obey mysterious laws but perfectly well known and definite laws. If a circuit is interrupted a definite obstacle is placed in the path of the carrier currents, and if they do get by it is only with a great deal of difficulty; so that this particular feature has led to the consideration of the establishment of special conductors for the carrier currents in some cases. In one case overhead ground wires will probably be used. They will be insulated for moderate voltage and the carrier equipment will be connected directly to these conductors. This will eliminate the chief difficulty that exists when using high voltage conductors. There carrier equipment can be connected directly to these wires, and thereby provide a more efficient circuit than is the case when it is necessary to use coupling wires or high voltage condensers to connect to the lines.

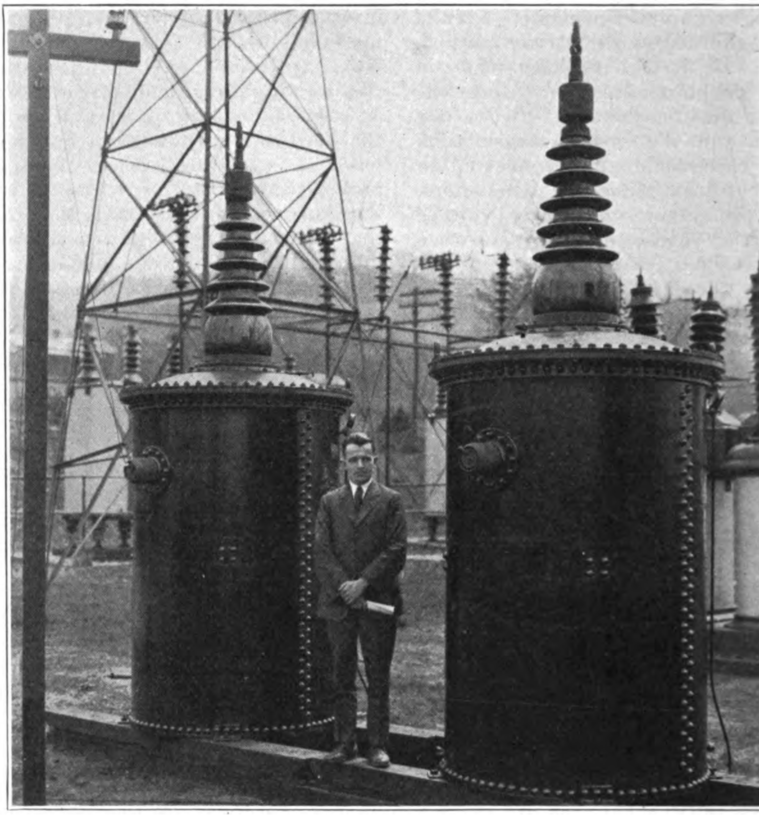


FIG. 5. COUPLING CONDENSERS READY FOR INSTALLATION ON HIGH VOLTAGE LINE.

DISCUSSION

Mr. Gage: I would like to ask what effect a defective insulator on the line would have, a defect not large enough to cause an actual breakdown but just a bad leaky insulator.

Mr. Slaughter: I don't know that you can say in very definite and quantitative terms just what the effect would be, but perhaps I could cite an instance which would give you a partial answer. In one of the carrier systems which was installed about a year ago in Pennsylvania it was noticed that the power transmission line gradually became increasingly noisy, in so far as the carrier system was concerned. It was in the fall when it was very dry. This was rather a puzzle to the power people because they had thought that the drier the line the better the insulation would be, and a good deal of speculating was done as to the cause of this trouble. Finally, an inspection by one of our engineers disclosed a sparking or crackling noise outside the substation. It was found that this was due to very small electric spark discharges taking place between the power transmission line conductor and some bolts which were in the wooden framework of some lightning arrester coils in the power transmission line conductors. You have probably noticed some coils around the power stations or substations, outside. When the wood was damp it was sufficiently good as a conductor so that the leakage currents required to charge up this bolt traveled through the wood. The wood got dry and the leakage currents could no longer travel through the wood so they jumped through the air. You could hear the noise 50 yards away through the air, and could hear it very plainly in the

power transmission carrier system. It was caused by small oscillating discharges between the bolt and the conductor. Discharges which you can hear as you walk along a power line, due to leaky insulators, will undoubtedly make a noise in the carrier system, because they will set up transient high frequency currents which will be transmitted along with the carrier high frequency currents, but it is a little hard to state in quantitative terms just what the extent of the disturbance would be.

Mr. Gage: Mr. Slaughter's answer was entirely satisfactory. I did not expect to get any definite quantitative terms, merely to know if there was probability of some disturbance. This reminds me of an experience in 1921. We were detailed to make an investigation as to the possibility of communication over underground cable lines which the telephone engineers tell us is not practical, and of course which we knew at the time, but over short distances it was hoped it might be possible. It was found with the use of considerable power for comparatively short distances, for 100 watts for transmission over distances of two of three miles at a frequency of about 100 kilocycles that underground lines could be used very effectively for carrier current. However, it was found that up to the point where the line reactors were installed there was good transmission of speech, but the line reactors effectively blocked the transmission past that point.

On the overhead or the distribution system, by putting voice current on the bus in the substation and coupling through potential transformers it was found that none of it got out of the 60 cycle circuits. On investigation it was found that the voltage regulators, which are simply reactances, were forming an effective block, preventing the transmission of voice currents over the 60 cycle line or circuit. On circuits having no voltage regulators it was found that in all parts of the circuit extending out two or three miles from the substation the voice could be taken out of any lamp socket in any customer's premises, but in order to effect any general distribution it would have been necessary to by-pass each voltage regulator with a condenser, and as Mr. Slaughter is going to show later, those condensers are very expensive devices.

Question: How many messages is the Bell Company able to send over carrier telephony, not the power lines but the regular system of the telephone company?

Mr. Slaughter: Four is the regular number, four carrier channels over a pair of wires, in addition to the other normal uses of the wires.

Question: In connection with the distribution of orders to emergency crews and power company and electric light companies or street railways, I wonder if Mr. Slaughter knows whether or not it is possible to make use of the 600-volt direct current distribution system of street railways for this purpose. I noticed in General Electric Review it says "The equipment has a normal range of about 30 miles along a straight transmission line, which is free from intervening taps or connections." On our feeders leading into the substations, each feeder is connected with a pair of choke coils. I wondered if that would prevent the use of these feeder lines for this system.

Mr. Slaughter: It can be said that any inductance in the circuit, of which these coils are an example, will be an obstacle to these high frequency currents. As to the use of carrier currents over trolley feeders, that has been given considerable attention up to the present time. Nothing very satisfactory has been evolved in the way of a system that is applicable to that particular field. No doubt if there is a sufficient need for it, and I am inclined to think that there is, the development of suitable systems will undoubtedly occur, but there is nothing at the present time which is commercially available for that purpose.

Fig. 1 shows a complete carrier telephone terminal in schematic form. Next to the power conductors are fuses and disconnect switches, then the high voltage coupling condensers and protection equipment. The carrier panel assembly is in the center, with a local or operator's telephone set just above, and an extension telephone set to the right. At the lower right-hand is the power supply, consisting of storage batteries and a small motor-generator set.

Fig. 2 is an actual installation of the carrier panel assembly. The protection

equipment shown in Fig. 3 is installed above, and the remaining equipment, less batteries, below. Notice the compactness of the carrier equipment. At the left are the transmitting and receiving panels and filters, at the right the power control panels.

Fig. 4 is a schematic circuit of the protection arrangements provided to prevent power currents from entering the carrier equipment. At the left are fuses, switches and high voltage coupling condensers, together with an outdoor type of horn gap. Within the building (shown in the two dotted line squares) are the two units of protection equipment containing the elements as shown. The one to the left has heavy duty coils, of low impedance to ground for power currents, and at the same time of suitable characteristics to transmit carrier currents efficiently. At the right is a combination switch, fuse and gaps, and beyond are additional coils and condensers designed to stop any remaining trace of power currents and to pass carrier currents freely. The vacuum gaps and insulating transformer complete a scheme of protection that has in actual trial never been called upon to use its last line of defense. No noticeable disturbance has yet gotten beyond the first set of coils.

In addition to its protective features, the entire circuit operates as a filter to transmit the carrier currents efficiently and exclude others.

Fig. 5 shows two high voltage coupling condensers suitable for use on 120 Kv. lines.

Reconstruction of White River Bridge, De Valls Bluff, Ark. for C. R. I. & P. Ry.

Presented March 30, 1925

By A. S. Armstrong*

This is a plain story of a difficult bit of construction, written as an engineer would write it — a simple statement of facts. A story writer would take these dramatic incidents such as the piers slipping out from under a main line railroad bridge, the floods, the derrick barge sinking at a crucial moment, the steamboat collisions and the stout-hearted men doing the work — and weave around them a first class romance. Read this article and notice the difference. —Editor.

THE White River rises in northwestern Arkansas in the Ozark Mountains, flows through the southern part of Missouri into the northeastern part of Arkansas, and thence southerly through the State emptying into the Missisipi at the mouth of the Arkansas. The White River has the longest deep channel of any river in the United States. The drainage area at the Rock Island bridge is about 24,500 square miles with a waterway of approximately 45,000 square feet.

Floods on the White River, which generally occur during the months of January to May, are caused entirely by rain in northern Arkansas and southern Missouri, as the area drained is too far south to have any accumulation of snow. The average stage of water during the flood months is approximately 24 ft. above low water, while during the summer months it is approximately 12 ft., low water stage being at about 33 ft. below base of rail. The highest stage recorded at bridge was 5 ft. below base of rail or over the top of the masonry and against the lower steel of the spans.

In early days, the White River was practically the only avenue of travel to and from a large portion of central and southern Arkansas, with a large amount of river traffic, which since the advent of the railroad and improved highways has diminished until today there are but few boats plying, none of which carry merchandise or the like.

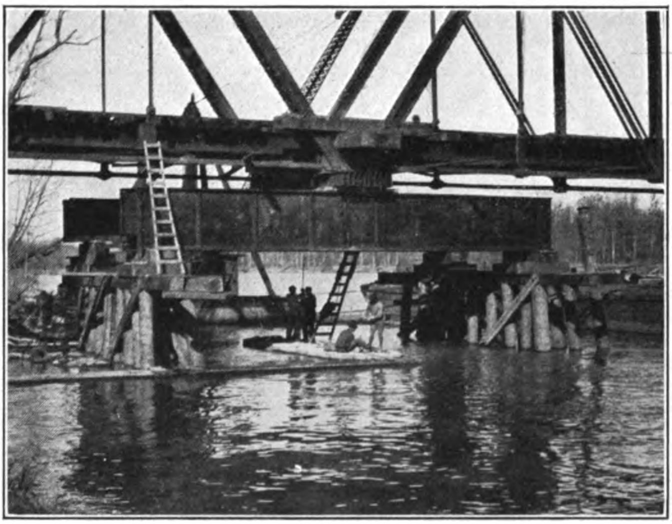
In 1853 a railroad which was incorporated as the Memphis and Little Rock R. R. was projected with these two cities as terminals. It was built and put in operation in 1859; by 1862 this line was

*Superintendent, Bates & Rogers Construction Co., Chicago.

complete, except a gap of 45 miles from De Valls Bluff to Madison. Traffic was opened with train leaving Little Rock at 8 A. M. for De Valls Bluff, then by steam boat to Clarendon 24 miles below, then by stage coach to Madison, thence by rail to Hopefield across the Mississippi from Memphis. This trip under good conditions took 32 hours, while today the trip is made in four hours. After the Civil War the M. & L. R. R.R. Co. received Government aid and a contract was let to build a bridge across the White River at De Valls Bluff. This was done in 1870 and in April, 1871 the two ends were connected. The M. & L. R. R.R. sold to the Choctaw & Memphis R. R. in 1898, then the C. O. & G. R. R. in 1900 and eventually became part of the Rock Island lines in 1904.

The original construction of 1870 consisted of three 150-ft. combination timber and iron How truss spans and one 220-ft. draw span with an unknown length of pile trestle approach. The spans were supported on masonry piers. It was not an easy task to bridge a stream of this character where the current is swift, even at low water and where the fluctuations between high and low water are as marked as in this stream, but that the engineers of that day did their work well, is evidenced by the fact that these piers stood for a period of fifty years through ever-changing conditions and increased loadings.

In 1900 when the road passed into the hands of the C. O. & G. R. R., combination spans were replaced with steel spans. New steel had been ordered but was used elsewhere, so it was decided to use the second-hand spans, which were available, but of unequal length none being the exact length required. Respective lengths were 146 ft. 4 in., 147 ft. 11 in., 150 ft. 2 in. To use them it was necessary to load the piers eccentrically. Several courses of stone were removed and the tops of the piers corbelled out.



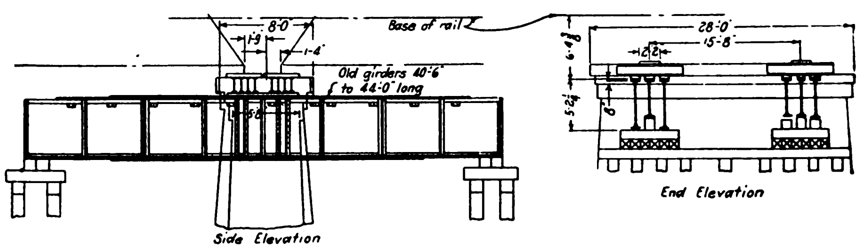
OLD SPANS SUPPORTED ON FALSEWORK READY TO REMOVE OLD PIER

In 1902 the C. O. & G. R. R. was absorbed by the Chicago, Rock Island & Pacific R. R. The Rock Island has since rebuilt the approaches so the structure consisted of 92 panels of ballast-deck pile trestle on east approach, a swing draw span of 220 ft., three pin-connected through truss spans and 52 panels of ballast-deck trestle on west approach. The total length of structure is 2,690 ft.

The steel spans were of E-35 design, but were strengthened in 1910 to carry the 1700 type of engine. Unfortunately

in the various changes of ownership, plans of the construction of the original foundations were not turned over to the Bridge Dept. of the Rock Island, so nothing was definitely known as to the depth or style of same. When the piers commenced to show weakness in 1920 the only explanation available was on account of scour in the river. However, at that time the cause could not be ascertained as the water was at a stage considerably above the low water and there was no evidence of scour, as rip rap originally placed was still around the pier. Partly due to the eccentric loading, cracks began to appear in and below the bridge seat of Pier 5. Immediate measures were taken to overcome this condition. The local bridge crews bound the top of the piers with steel cable, which offset, to some extent, the disrupting forces. However, late in the summer of 1921, inspection showed Pier 4 had moved east 14 inches, 3 inches by leaning at top and 11 inches by bodily sliding on its foundations. Pier 5 had a crack 2 in. wide the full length of the pier from three to five courses deep, while the deepest part of the river was 57½ ft. below the base of rail, as against 44 ft. below base of rail in 1899.

On account of the White River being a navigable stream, application was made to the U. S. Government on September 13, 1921, to rebuild Piers 4 and 5, which was granted October 5, 1921. The contract was awarded November 1 and the floating plant arrived December 12. The stage of the river at this time was too high to drive falsework for supporting the spans during construction of piers, so all that the contractor did in 1921 was to build platforms at the west end of the bridge for storing material and equipment above high water and erect the concrete plant. By January 7, 1922, the water had fallen sufficiently to permit driving of falsework. The falsework consisted of two bents of 18 piles each, driven on both sides of each pier and so located as to make a clear span of 32 ft. to permit the removal of the old pier and construction of cofferdams for new work. Carrying girders, built up out of three second-hand deck spans, were designed especially for this purpose. On the girders a grillage of 15-in., 42-lb., I-beams was placed with a cushion of 4x12-in. oak blocks between the girders and grillage. The bridge shoes rested directly on the grillages.



DETAILS OF FALSEWORK OVER THE OLD PIERS

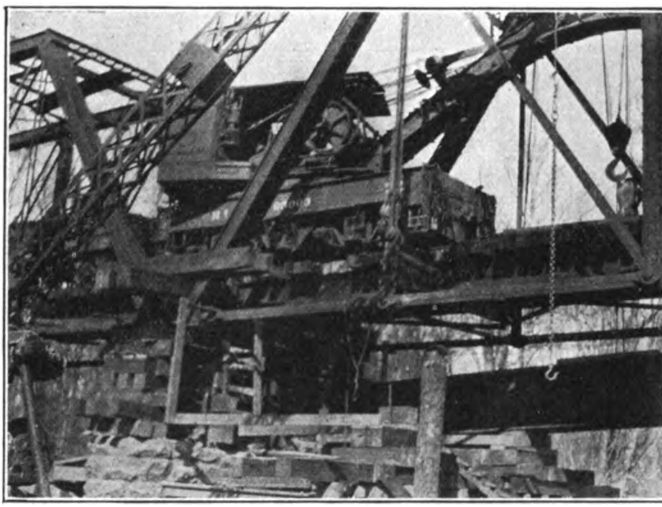
In placing the girders and grillages, the first move was to cut away as much of the stone masonry as was considered safe between the outside of the shoes, to a depth sufficient to clear the bottoms of the carrying girders. The girders and grillage were then loaded on a barge and floated to the pier, where they were placed on the falsework, and as close to the remaining masonry as possible. Heavy 12x12-in. timbers were lashed to the inclined end posts with steel cable and the spans lifted with jacks working under these timbers. The remaining stone was taken out, the girders moved transversely to position, and the jacks lowered. By making preparation in this manner, it was found the load could be transferred to the falsework in a minimum of time and with minimum of effort.

Removing Old Piers

After the girders were in place the balance of the pier was taken down to the water line. Presumably the masonry was set in a lime mortar, but it was found to be exceptionally hard and tenacious, and fully as good as a Portland cement mortar. When the water line was reached, the remaining portion of the pier was drilled to the bottom with eight 1¾-in. holes and blasted. A dredge with an orange peel bucket was then put in and the material taken out to the footing. It was found that when the bridge was originally constructed, white oak timbers 14 in. x 14 in. and running in length from 20 ft. to 26 ft. very carefully hewn and given a flat point, apparently to a template, had been driven in the form of a cofferdam, and tied together with 1¼-in. rods, and two lines of waling, one inside and one outside. This enclosure was then filled to the top of the timbers with spalls and finer stone and the pier built up on this as a platform, but without extended footings.

The cause of the failure of the pier was also disclosed. It was apparent that these timbers were driven during a low stage of the river, and had at that time been substantially at the water's surface. During the fifty years since, occasional periods of low water, sufficient to expose the timbers, have occurred, and eventually enough decay had taken place to permit the crushing of the waling pieces and the consequent spreading of the old cofferdam.

An effort was made to pull them out with the orange peel bucket, but this was not successful, as too much time was lost owing to the fact that there was 18 ft. of water with a swift current over the foundation. Finally tongs were fashioned out of two 30-ft. 85-lb. rails, and they were removed more easily and rapidly.



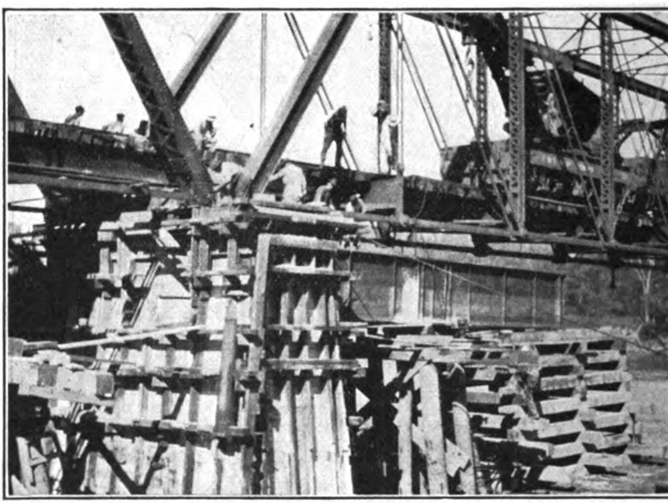
SWINGING THE CARRYING GIRDERS INTO PLACE

The removal of rip rap and excavation of sand preparatory to placing the cofferdam was started, but the river, was raising and work closed down until summer, the early part of April. The water reached 9 ft. below base of rail. Operations were resumed again on June 1, 1922. On June 8 the cofferdam was started. The cofferdams were constructed in the following manner. Six wooden piles were driven outside of the cofferdam to support an outer line of waling which in time kept the steel sheeting plumb. When these were in place the inner timbers for supporting the cofferdam were placed. On Pier 5, five horizontal rows of waling were framed, the exact size of the cofferdam, or 2 ft. larger than the

neat foundation plans, and spaced 4 ft. apart; after all were in place U. S. steel sheeting 45 ft. long, 38-lb. section was put in place and driven. Under the girders, the clearance was such that shorter lengths were used and spliced together with 7-in., 16¼-lb. channels and ⅞-in. bolts. This would have been very difficult on account of small clearance, if individual pieces were entered underneath the girders, which would have required the use of numerous short pieces and many splices. This was partially overcome by assembling pieces to span each set of girders before placing underneath and swinging into place and making closure on each side. The sheeting was driven with a 2,800-lb. drop hammer, after which the remainder of the excavation was removed with the orange peel dredge. The excavation was carried to about 3 ft. below plan depth to allow for swell in driving foundation piles.

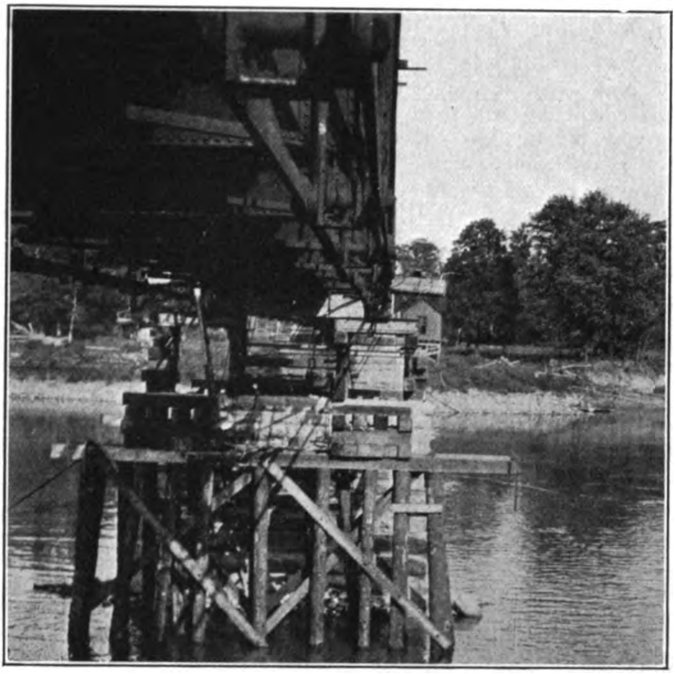
On June 27, 1922, piles of gum or oak, 40 to 50 ft. long were driven with a No. 1 Vulcan Steam Hammer to below surface of water giving average penetration of 15 ft. This work was finished July 11.

As the material in the foundation was a fine sand, no attempt was made to pump out the cofferdam until a 6½-ft. sealing course of concrete was placed. The concrete for the work was mixed at a plant erected at the west end of bridge. The mixer was elevated so as to discharge directly into bottom-dump cars of one cu. yd. capacity operated on the guard rail of the bridge. The aggregates were fed to the mixer with a guy derrick. The cars transporting the concrete were removed from track by the derrick to permit passing of trains. Concrete was dumped from cars into a hopper attached to the bridge, and deposited through a tremie made of 8-in. wrought iron pipe with a small hopper at the top. The tremie was supported from the boom of the derrick barge, and concrete run from the main hopper under the bridge to the tremie through wooden chutes.



PIER 3 COMPLETED AND GIRDERS BEING REMOVED

Sealing was completed July 20 and allowed to set five days. Three 8-in. centrifugal pumps were installed to pump out the cofferdam. With only a single row of steel sheeting for a cofferdam and a head of twenty-five feet of water considerable leakage through the steel was anticipated so a carload of front-end locomotive cinders was on hand to use in stopping the leaks. This was done by pouring them from burlap sacks on the outside after the pumps were started. This method was so successful that after once pumped out, one 8-in. pump would



END VIEW SHOWING FALSEWORK READY FOR THE TEMPORARY GIRDERS

handle the water. There were no leaks through the bottom.

After the water was out the foundation piles were cut off directly above the sealing and a 2-ft. course of concrete placed over the entire footing, on top of which the main body of the pier was built. This work was completed August 10. On September 8 the girder was removed from pier 5 to pier 4. Previously the truss spans on pier 5 had been raised and permanent I-beam grillages placed under the shoes across the opening for girders. The openings were then filled with concrete and coping of the pier completed. New end braces and pedestals to support stringers were placed and pier 5 completed September 25.

The operations on Pier 4 were very similar to Pier 5. Started to drive falsework August 18, set supporting girders from Pier 5 September 8, removed old pier September 13 to 27, started to drive sheeting October 3, completed excavation October 21, drove foundation piles October 22 to 28, completed sealing November 5. About 9 ft. of sealing was placed in this pier on account of foundations being deeper. Cut off foundation piles November 11, finished pier December 1, 1922.

When Piers 4 and 5 were completed it was thought that all immediate danger was eliminated. However, the cross currents caused by erosion of the east bank both above and below the bridge, made it hazardous for steam boats to pass through the draw, which has a clearance of 91 ft. between pivot pier and pier 3. The river men were entering continuous complaints. On March 22, 1923, a steamer with tow hit pier 3 and pushed four north courses of masonry out of place; a few days afterward a towboat with tow going in the opposite direction hit the pier pushing the stones nearly back in place. On July 6 the pier was showing signs of failure; it had settled 3 in. and moved south 4¼ in. By July 15 it had settled 4 in. more and it was decided to place the spans over it on falsework at once, using the same falsework girders from Piers 4 and 5. In the meantime plans for a complete

rebuilding of the bridge were made. At a meeting with the U. S. Engineers in Memphis, plans were approved for the removal of the draw span and pivot pier and their replacement by lift span 187 ft. in length giving 175 ft. clear channel. Piers 2 and 3 were consequently designed to carry one end of the new lift span and an adjacent new fixed 150-ft. span.

The falsework for Pier 3 was completed in September, the removal of old pier was started October 12. November 24 the cofferdam timbers were placed. The bottom footing of this pier was 14 ft. deeper than Pier 5, so seven horizontal rows of waling were placed with cross braces of 12 x 12-in. timbers spaced 8-ft. centers. The bottom of footing was 66.7 ft. below base of rail, while excavation was carried to 69 ft. to allow for swell in driving piles. The cofferdam being 30 x 52 ft.. 50-ft. spliced steel sheeting was used in this pier. All excavation and cofferdam work was completed December 12. A rise in the river at this time stopped further work until January 30, 1924, an attempt was made to work during the early part of February, but another rise caused almost complete cessation until July 29. The water was still too high to drive the 40-ft. to 50-ft. foundation piles on hand, so 15-ft. to 20-ft. piles were spliced to them by means of 3 x 12-in. scabs spiked with 8-in. spikes, making 60-ft. to 65-ft. piles. There were 214 piles driven with 12½-ft. penetration by No. 1 Vulcan Steam Hammer and 0.17-in. penetration on last blow.

Sealing was completed September 3, 12.5-ft. of concrete being placed by the same method as used on Piers 4 and 5.

Pumps were started September 8 and additional bracing placed as the water was lowered. Pumping was completed September 10, cut off piling September 11, poured 2-ft. 6-in. concrete September 12, completed main body of pier September 29, falsework girders were removed October 28, grillage placed and cap placed October 29.

Pier 2 is for a new bridge in a new location consequently built without falsework. For years the east bank had been covered with heavy stone to protect the bank from scour of the river. This had to be removed before steel sheeting for the cofferdam could be driven. It was feared that removal of material so close to old Pier 1 would endanger this pier so cofferdam timbers were placed on October 1 and the first row of sheeting driven by October 20. Excavation was then carried on inside the cofferdam by means of the orange peel dredge.

On November 5 cracks appeared behind Pier 1 and observations taken showed that it was moving forward at almost an inch a day, also setting ¼ to ½ inch. This pier was watched carefully every day and continued to carry the draw span until its replacement by falsework in February 1925, when it had moved 20-in. and settled 9-in. Movement of the east pier was followed by a sliding of bank until it gradually forced the top part of the cofferdam over about four feet. On account of this crowding, it was possible to place only five sets of waling before pumping, so it was decided to place more sealing concrete and not pump down so far. On December 3, at a time when the work was being rushed in anticipation of high water, the derrick boat sank in about twenty-five feet of water, which delayed work until the boat was raised, repaired and ready for service on December 16. In the meantime a guyed derrick was installed at the downstream end of the pier. After the derrick boat was again fit for service, excavation was resumed, completing the upstream end of the cofferdam by the night of December 16. Immediately afterwards foundation piles 65 to 70-ft. long were driven to 20-ft. penetration with the aid of a jet pump in the upstream end, while excavation was still proceeding in the down-stream end. A rise in the river stopped further work from December 23 to January 3. Next day, however, pile driving was resumed during a cold wave and the last piles were driven January 10. The sealing course 16-ft. thick was placed at once and finished January 14. Concrete was allowed to set 5 days and pumped out to 2 feet below the last row of waling. Piles were cut off with a specially made saw 4-ft. below water. Then an additional 6-ft. of concrete was placed and the rest of the pier built on this foundation. Concrete work was finished February 5. Shortly afterwards,

work was shut down until summer in expectation of the spring flood.

On account of the gradual scour of the east bank, another new Pier (No. 1) will be built 150-ft. to the east of Pier 2 and an additional 150-ft. truss span will supply increased opening. Work on this pier will commence as soon as the stage of the water permits.

All materials used were furnished by the Company, and all the equipment, except track equipment, was furnished by the contractor. The Bates & Rogers Construction Co. of Chicago were the contractors.

The work was done under the general direction of C. A. Morse, Chief Engineer, and I. L. Simmons, Bridge Engineer. Bert Matheis and H. Bober were engineers in charge.

Quantities

	Pier No. 5	Pier No. 4	Pier No. 3	Pier No. 2	
Base rail to bottom of steel sheeting	56.0 ft.	62.0 ft.	68.5 ft.	70 ft.	
Length of sheeting	45 ft.	45 ft.	50 ft.	50 ft.	
Base rail to bottom of footing	52.7 ft.	58.1 ft.	66.3 ft.	66.3 ft.	
Depth of sealing course	6 ft.	8.5 ft.	12.5 ft.	16.1 ft.	
Number of foundation piles					632
Concrete in pier, cu. yd.					4,646
Excavation, rip rap, cu. yd.					1,100
Excavation, sand, cu. yd.					6,800
Steel sheeting driven, lin. ft.					26,000
Cofferdam timber placed, ft. B. M.					115,000

Material Handling Problems at the Western Electric Company

By F. J. Feeley*

Presented April 13, 1925

Methods of handling enormous quantities of many kinds of material in process of manufacture are here described. Some manufacturers might be inclined to think that the methods here described are suitable only in large plants but careful study will show that proportionate savings may be made in smaller plants. In each case the equipment has been installed only after careful study has shown that the savings would more than justify the investment. Mr. Feeley used about sixty lantern slides to illustrate this paper.—Editor.

General

THE manufacture of telephone equipment involves the use of a large number of different kinds of material, and in many cases the quantities used are of such magnitude that the problems of material handling have required careful study. While we have not by any means arrived at the final solution of all of our problems, considerable progress has been made in the past few years on some of the more important ones.

The company's premises, which are devoted to manufacturing, cover approximately 113 acres. This is divided into three parts by the Belt R. R. and the C. B. & Q. R. R. The eastern portion contains the cable, rubber, and insulating departments, the wire mill and the junk cable reclamation departments. The western portion contains the telephone apparatus shops, the power house, the merchandise warehouses, and the foundry. The southern portion contains the lumber yards, box and reel factory, the lumber kilns, the woodwork mill, and the storage yard for coal.

Railroad Facilities

The plant is served by the Manufacturers Junction R. R. which takes care of all switching of freight cars. We have 24 miles of railroad track at Hawthorne, and freight cars can be switched to strategic points in the plant. The buildings are so laid out that the cars can be unloaded at platforms adjacent to raw material storerooms, and the trucking distance for raw material is consequently reduced to a minimum. The Merchandise Buildings, from which finished apparatus is shipped, have railroad tracks running through them and cars can be loaded from warehouse space on either side of these tracks.

The Manufacturers Junction R. R. switched an average of 110 cars a day for us during the year 1924, and required three steam locomotives to maintain this service.

Locomotives for the New Kearny Plant

We have recently investigated various types of switching locomotives for the new Kearny Plant now under construction. The ultimate plant will have a manufacturing capacity practically equivalent to Hawthorne's. The layout for this new plant which will be located between Newark and Jersey City, N. J. is somewhat more compact than that of the Hawthorne Plant, the actual ground space will be 67 acres or about 60% of the space available at Hawthorne.

If we were to use steam locomotives for Kearny, we would require two 60-ton locomotives for the general switching service, and a 40-ton locomotive of some other type, for the lumber yard, on account of the fire hazard. The steam locomotives would require considerable auxiliary equipment such as a round house, a turn table, a machine shop, coal, sand, ash and water stations and hot water feeders. In addition to being expensive, this equipment would take up considerable ground space, which is quite limited at the new plant. We found that we could handle the switching traffic more economically with two 60-ton battery locomotives, or with one 40-ton and one 60-ton combination battery and third rail locomotive, or with straight trolley or third rail locomotives of 40 and 60-ton capacity.

* Development Engineer, Western Electric Co., Hawthorne Works, Chicago, Ill.

Our decision was in favor of the plan calling for two 60-ton battery locomotives for the ultimate plant, although the operating expense was somewhat higher than was the case with the other types of electric locomotives. It will be of interest to point out the factors which influenced our decision in this matter.

(a) The investment for third rail or trolley required for the initial plant layout would be proportionately much larger than the figures for the ultimate plant would indicate, and the interest on investment and depreciation on this equipment would offset the operating economy for several years to come.

(b) Overhead wires would interfere with the operation of the locomotive crane, would be unsightly and more or less hazardous.

(c) Third rail construction would be complicated by the large number of crossings over roadways, and would be quite hazardous when the number of employees in the plant is taken into consideration.

(d) We had experience with operating a smaller storage battery locomotive, which I will mention later, with very satisfactory results.

(e) The storage batteries could be charged at night, when the load on the power house was very light, and consequently no additional capacity of generating equipment would be required, such as would be the case with the third rail or trolley types.

(f) A new type of oil electric locomotive recently introduced showed considerable promise, and it seemed quite probable that our second locomotive might be one of this type. Its adoption would of course make trolley or third rail equipment obsolete.

The items of depreciation, maintenance and repairs for the oil-electric type could not be determined over any extended period of time, and it was for this reason that we did not care to adopt it at this time. It has a big advantage over the storage battery type where long daily service is required. However, our service is such that we will have plenty of time to allow for charging storage batteries, and we therefore could not count this as an important factor for our particular application.

The 60-ton storage battery locomotive which we now have on order for the Kearny Plant will have 100 lead cells of 1800 ampere-hour capacity. It will have a speed of 16 mi. per hour running light and 5 mi. per hour with 17,000 lb. drawbar pull. We have considered these as safe speeds in a somewhat congested plant, and they are low enough to conserve the battery charge as much as possible.

Locomotive Cranes

While on the subject of locomotives mention should be made of our locomotive cranes, which have proven to be very useful pieces of equipment at Hawthorne. We use two steam cranes for a variety of service. They unload coal cars at our storage yard south of 26th Street and load them for delivery to the power house. Our power house is provided with a complete conveying system for coal and ashes, and hopper bottom cars are usually delivered there direct and are not unloaded at the storage yard unless there is a surplus.

One of the locomotive cranes is equipped with an electro-magnet for unloading pig iron at the foundry, and for loading steel scrap at the scrap bins. Locomotive cranes also unload coke for the gas house, and for the foundry, load incinerator ash into cars, and occasionally help out the Plant Department on the larger grading jobs.

The locomotive crane we are providing for Kearny will not handle coal. The storage yard for coal will be adjacent to the power house and special conveying equipment is to be provided for this purpose. The principal function of the locomotive crane at Kearny will be the handling of reels of lead covered cable, weighing up to 5 tons onto barges moored at the dock just west of the plant, and onto auto trucks. We have decided to use a storage battery type of locomotive crane. Although the investment required is somewhat higher than would be required for a steam crane, we expect the cost of operation will be lower, and the elimination of noise, smoke and sparks is also a desirable feature. This will be one of the first storage battery locomotive cranes to be built.

Our crane will be equipped with 100 lead cells of 1080 ampere-hour capacity. It will have capacity for handling 150 reels of cable per day, with enough reserve to shift occasional cars in the reel yard. A number of safety devices are to be applied to this equipment including load and radius indicators. We are also devising a system of cutout relays which will prevent the use of the boom for picking up excessive loads when it is in the danger zone at right angles to the length of the crane car.

Auto Truck Service

Coming back to the Hawthorne Plant I would like to discuss our truck service, which has developed into a department of large proportions. The large increase in the demand for telephone equipment in the past two years has made it necessary to expand the Hawthorne Plant to such an extent that outside manufacturing and warehouse space had to be leased. The transportation between the Hawthorne Works and these outside plants, together with the pickup service for supplies and materials purchased locally, and deliveries of small lot shipments to freight houses, formed a class of service which we found could be most economically maintained by five-ton gas trucks. The speed attainable with this type of truck makes it possible to cover a larger radius of travel than is possible with any other type of equipment. The relatively short loading times combined with the long hauls made the tractor trailer system less economical.

The truck service inside the Hawthorne Plant can be classified into three groups. The first is the tractor-trailer system which transports finished telephone equipment from the telephone apparatus shops to the Merchandise Warehouse, where it is packed, stored and shipped. This service amounts to about 100 trips per day, the average haul being about ⅓ of a mile per trip, and it is maintained by a gasoline tractor and three trailers equipped with closed bodies. The finished apparatus is loaded into the trailer bodies on shop trucks or transveyor platforms, which are unloaded at the warehouse and returned by the tractor and trailers to the telephone apparatus shops. The tractor-trailer system is ideal for this service, and comparing it with the gasoline truck service formerly used, it has reduced the cost of transportation fully 50%.

The second class of service is the inter-building traffic between various departments in the plant. It consists mostly of transportation of materials in process, but it also includes the delivery of manufactured product to the Merchandise Warehouse. The volume of this traffic grew to such proportions about two years ago that it became necessary to provide a considerable amount of new equipment. The nature of the service was such that it could not be properly maintained by a tractor-trailer system without using a large number of trailers, and the fixed charges on this equipment offset any operating economy which we might expect with this system. A traffic study showed that three 5-ton electric trucks would handle the service most economically. The service consists of short hauls with numerous stops, and a travel of approximately 20 to 25 miles per day per truck. The investment required was almost double that of gas trucks, but we estimated that the total cost of operation, including fixed charges, would be 25 to 30% lower. The figures for the past year indicate that the cost of operation was actually 35% less than the cost with the old gasoline trucks, making due allowance for the age of the trucks.

The third class of service consists of the delivery of small lots of material, and is used largely by the maintenance and millwright departments. Four electric load carrying trucks are used for this service, and we have found that this type of equipment is particularly well adapted for this work, as the trucks can be run onto freight elevators and can deliver material to any floor in practically any building. The lots of material handled are not large enough to justify an electric tractor-trailer system. The use of these trucks eliminates a large amount of hand trucking, and relieves the auto trucks of the small lot deliveries.

Manufacturing Operations

Referring now to material handling problems which apply more directly to specific manufacturing operations. Our product can be divided into two general classifications: cable and telephone ap-

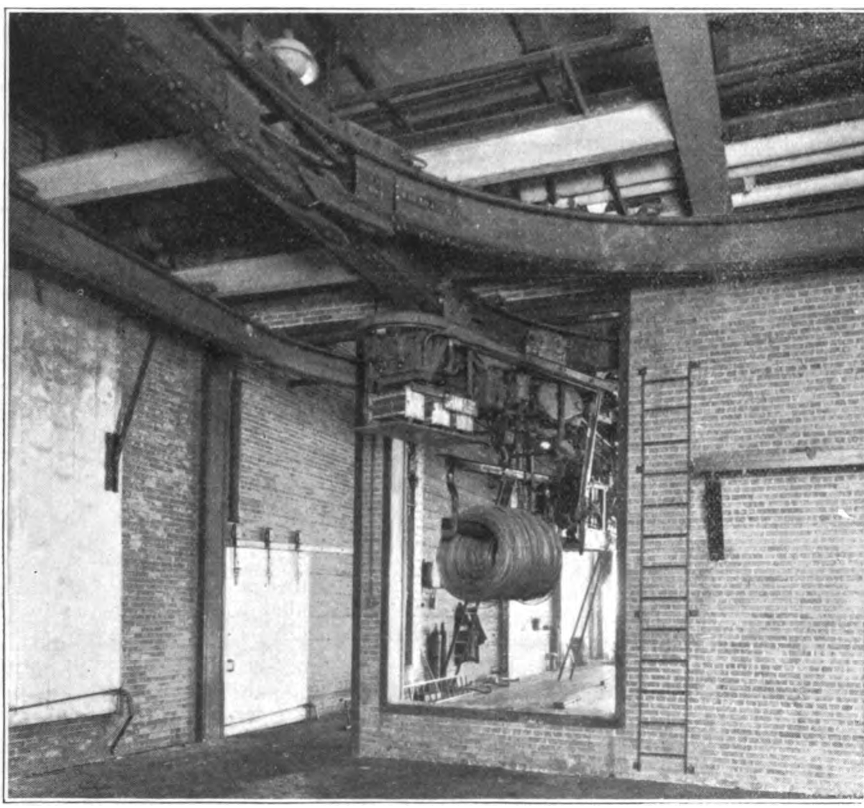
paratus. I will trace the manufacture of cable through the principal operations, and since it is my object to discuss the material handling question only, I will not go into operating details.

Lead covered cable is made up of copper wire insulated with paper, the entire cable being sheathed with an alloy of lead and antimony or lead and tin. At the present time our output of cable amounts to about 600,000,000 conductor feet per week which means that we actually use about 6,000,000 miles of copper wire per year.

With this enormous consumption of wire it was quite logical for us to erect our own wire mill. We have just completed such a project and we have a mill which we can safely say is producing copper rod and wire at a higher rate of speed and with more output per unit area of floor space, than is produced by any other wire mill in existence.

Many interesting engineering problems came up in connection with the development of our wire mill, which are quite radical departures from recognized standard practice. From a material handling standpoint, the most interesting feature is the monorail system of transportation. It is the most comprehensive material handling project which we have in operation at this time.

The plant is divided into two main divisions. The section at the south end is the rod mill which rolls the billets down to ¼-in. or $\frac{5}{16}$-in. rod. This section also contains the pickling and rinsing vats. The north section is the wire mill proper. The copper rod is drawn in the wire drawing machines into wire ranging



MONORAIL HOIST USED IN ROD AND WIRE MILL

in size from 0.165-in. line wire down to 40 gauge wire.

Monorail System

A monorail system covers the pickling and rinsing tanks and the storage area in the rod mill. This storage area is effectively covered by a transfer bridge which carries a monorail. The monorail cars or hoists can be transferred to this movable bridge, which in effect becomes a bridge crane, with the monorail car taking the place of the trolley. This combination forms a very flexible system, and it enables us to transport coiled rod from any part of the storage area to the pickling tanks, or directly to the wire mill, or to the shipping platform at the east side of the building.

When we handle coiled rod, we insert a wooden beam through nine coils, which the hoist can pick up and transfer to the pickling tank. These loads can be picked up or released by the hoist operator without the assistance of a ground man.

When delivering the rod to the wire mill the operator can run his car along either the east side or the west side of the group of wire drawing machines. He deposits his load in bins which are adjacent to the outside machines in each row. The monorail switches, which are of the fixed tongue type, are operated by the man on the car as he approaches a junction, and he can do this without stopping the car. We have found that there is a limit to the speed at which the car should approach the switch, but the operators are now well trained and cover their traffic routes with no hesitation or delay.

Spools of wire are loaded onto platforms or skids which are placed under the monorail system. These platforms are delivered by the monorail cars to the inspection department or to the annealing furnaces and to other succeeding operations. The man on the monorail car picks up these skids and releases them without ground assistance.

The monorail cars operate at a speed of 350 feet per minute and have a capacity of two tons. The hoist operates at a speed of 28 feet per minute, and it is equipped with a limit switch to prevent over-travel. The load is raised until it clears the floor by six feet, three inches before travel is started. We operate the system on 220 volts direct current.

Reduces Building Cost

Before adopting the monorail system of handling material in the wire mill, a careful study was made of other systems of transportation. The monorail system enabled us to eliminate trucking aisles which made it possible to reduce the width of the building at least 21 feet less than what would have been required if an industrial truck system were used. The monorail system also made it possible to transfer material directly from the rinse tanks and rod storage to the wire drawing machines. The use of a monorail system also made it possible to esablish definite lines of travel which could be more easily guarded from accidents than trucking aisles. Material could also be handled more expeditiously and with less commotion than would be possible with trucks.

Rod Rolling Process

We have found that we can use electric trucks to advantage in unloading copper billets from box cars. The billets weighing about 200 lb. each are loaded onto platforms, which are picked up by an electric lift truck, which delivers them to the storage space at the south end of the rod mill.

At the billet heating furnace we have an air hoist which is equipped with a special lifting device for picking up six billets at a time from a loaded skid. The billets are placed on the furnace track and are forced through the furnace by a compressed air ram which comes into operation for each group of six billets. The billets are removed from the side of the furnace near the north end, by a long pair of tongs which is supported from the trusses overhead, and pivoted so as to give the roller a leverage for handling the heavy billet when feeding it into the roughing rolls.

When the rod is completed it is fed into coiling devices which are equipped with air hoists for lifting completed coils of rod up to the level of a conveyor adjacent to the coilers. Shifting devices push the coils onto the conveyor. These devices are interlocked, and are connected to a signal system which indicates to the

roller at the last pass which coilers are up to speed and available for use.

A conveyor which carriers the coiled rod under a cooling spray is so designed that at the end of its run, it elevates the coils and discharges them onto a truck placed on a transfer car. Coils are deposited on this truck so that their axes are horizontal and when nine coils are in place the transfer car is shifted and another truck is brought into position. At this point the monorail system takes care of all operations in the manner previously described.

Finished Wire

Finished wire on spools is handled on transveyor platforms, the larger part of this wire being delivered to the Cable Plant. Various schemes for transporting wire to the Cable Plant were considered, including a tractor-trailer system and special industrial trucks, but the least expensive method of transportation was found to be the use of our 5-ton electric trucks previously mentioned.

Insulated Wire

Copper wire and paper are delivered to the insulating machines in the Cable Plant on hand trucks. The insulated wire on reels is transported from the insulators to the twisting machines on hand trucks and from the twisters to the stranding machines on deck trucks.

The stranding machines strand the wires into a round cable and wrap a paper covering around it. The cable as it is delivered from the capstan of the stranding machines is wound on what we call a core truck which is merely a rotatable drum mounted on wheels. After it is inspected the cable is placed in drying ovens, from which it is fed through the lead presses which extrude the lead sheath over the cable. The lead covered cable is wound onto wooden shipping reels which are driven by rollers set in the floor of the lead press room. Up to this time the material is moved from operation to operation on hand trucks due to the fact that the trucking distances are relatively short. Other methods of handling are under consideration at this time, but with the present layout of the Cable Plant, the hand trucking methods prove to be the most economical.

Handling of Lead

From the standpoint of weight, lead is our largest item of material handling. We are using about ten carloads of lead per day, which is about one-eighth of the total lead produced in the country at the present time. Cars loaded with lead are switched direct to the lead press room and the pigs are loaded onto skids which are brought out onto a platform under the cranes which span the lead press room and run the entire length of it. The crane is equipped with a crane scale for checking the weights of skid loads of lead as they are being transferred to the storage pit. The delivery of lead from storage pit to the melting kettles associated with the lead presses is performed by either of two cranes. One of these cranes has a capacity of 20 tons and is also used for transporting reels of cable and for handling heavy machines. The other crane has a capacity of 8 tons and is used for handling lead only.

We are trying out a new method of handling lead to eliminate manual labor now required to load skids and pull them out of the cars. The receiving platform level is designed for the average height of box cars and when we have lead delivered in box cars which have an unusually high or low floor, we find that it is an extremely hard job to move a skid load containing 5,000 pounds of lead out of the car onto the platform. To overcome this difficulty we are making arrangements with the lead companies to bind bundles of lead pigs with wire so that the lead can be unloaded from the car by an electric lift truck. Trial shipments are to be made and if this works out as we expect it to, it will eliminate one of the most arduous manual jobs that we have at our plant.

At the north end of the lead press room we have an armoring machine which is used for stranding jute and steel wire onto lead covered cable. This cable is sometimes called submarine cable but it is more properly named armored cable and is used for stretches under rivers or bays. As this cable is rather difficult to splice, it is made in long lengths and a reel of it will weigh as much as 35 to 40 tons. We have provided a 50-ton crane which spans the armoring room so that

the largest and heaviest reels of armored cable can be picked up and placed on a flat car.

Handling of Lead Covered Cable

After the lead sheath is put on cable the reels are rolled into a room adjoining the lead press room where the cable is inspected. The room just west of the inspection room is the shipping room where the reels of cable are covered with wooden lags.

Some cable is shipped direct by car from the shipping room, but by far the larger portion of it must be held in storage for the completion of orders or carload shipments. We store this cable out in the open because of the amount of space required for this purpose.

A special reel-carrying trailer has been developed for transferring the reels of cable to the reel yard which is located at an average distance of about 1,000 feet from the place where the reels are lagged. With the old method of transferring reels we loaded box cars at the shipping room and switched them out to the reel yard track where the reels were unloaded and placed in storage. We have found that the reel carrying trailer can do this work much more economically as it requires very little manual labor to handle the reels. This trailer consists of an open-end truck provided with two jack screw lifts, one on each side. The jack screws are driven through gearing by a motor which receives its power from a storage battery electric tractor used for pulling the trailer. To pick up a reel the tractor operator backs the trailer up to it, and since the trailer is an open end affair it is possible to position the lifting jacks directly under a bar which has been previously inserted through the hubs of the reel. The motor on the trailer is started by the operator on the tractor and the reel is lifted usually about two inches above the ground, which is just enough to clear obstructions. The operator then starts up his tractor and pulls the load out to the yard and deposits the reel on the ground and returns for another one. The trailers are designed to pick up reels varying in diameter from 42-in. to 84-in. and from 31-in. to 40-in. in width. These reels of cable will weigh up to 10,000 pounds and a tractor and trailer will handle about 100 reels per day. This system has worked out so successfully that we have decided to adopt it in place of the old method and are purchasing an additional unit similar to the one just described, with a third tractor which we intend to use on night service.

Cable Reel Storage

While on the subject of lead covered cable I might mention our new reel yard project which will greatly facilitate and cheapen our cost of handling reels of cable between the storage yard and the shipping track. This project is one of considerable magnitude and we have been recently authorized to change track layouts, provide runways and overhead cranes, both for handling the loaded reels and the empty reels together with the tractors and trailers just mentioned. We will have two sets of tracks placed in the center of the storage space. The first part of the project calls for the installation of the west half only. The area used for the storage of loaded reels will be spanned by a bridge crane having a span of 110 feet and a capacity of 7½ tons. The east track of this crane will be supported by columns between the two railroad tracks which will be located in the center of the ultimate layout.

The west track of this crane and the east track of a crane which will span the empty reel yard will be built on a common support. The tractors and trailers will operate on the roadway located at the west side of the space for loaded reels under the crane, and the reels of cable will be brought to a point nearest the location previously determined for the reel. The reels of cable are all numbered and their position in the reel yard will be predetermined so that all the reels of any one order will be located in approximately the same section in the reel yard. This will minimize the travel of the crane when loading cars. Most of our cable shipments are made in box cars because they are the most convenient to unload at the receiving points. Occasionally, however, we make shipments in gondola cars and the craneway is so laid out that the reels of cable can be loaded directly into them.

The saving in handling due to the elimination of hand methods will make it possible for us to realize a return of

about 25% on the money invested in this reel yard project. A great improvement will also be brought about in the labor situation which has in the past been quite acute at times, especially in the winter time when the ground is covered with snow.

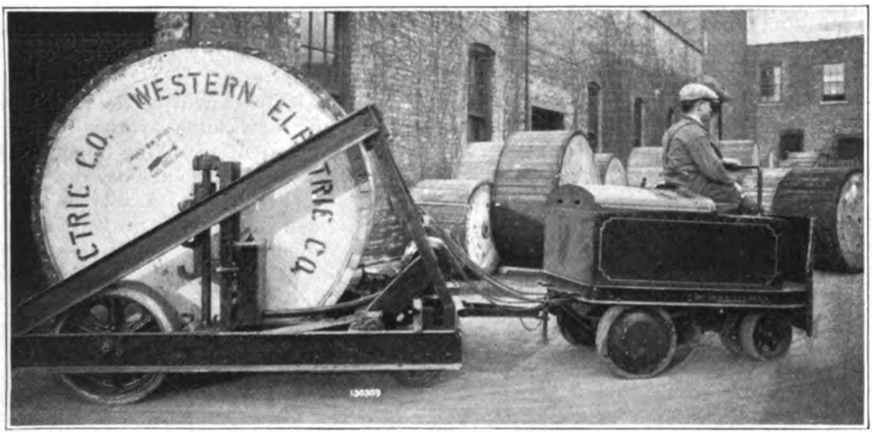
Handling Empty Reels

The handling of empty reels has also proven to be a very interesting problem. An average of about 200 empty reels are returned each day by the telephone companies. Most of these reels need repairs of one kind or another, and are repainted before they are sent out again. We have been storing these reels out in the yard by letting them stand on their rims, and we repair them as the requirements of the Cable Plant demand.

The reels stored in this manner take up a large amount of space and there is a tendency for the rims to rot when they are allowed to stand out on wet ground for any length of time. Part of our reel yard project will provide means of handling these empty reels so that they can be stacked on their sides up to a height of about 4 or 5 reels. This method of storing enables us to reduce the space required to about 40% of that required by the old method of storing, and it also protects the edges of reels against rotting.

Reels as they are delivered to the yard from the reel shop will be rolled down a tilted runway which will turn them over on their sides against a rubber bumper. They will be picked up by an electrically operated device which will be dropped into the hole in the reel hub. After the reel is in place on the pile it will be released by the crane operator.

We have considered the feasibility of the crane delivering the reels directly to the Cable Plant, but the layout is such that the expense for the added crane runway would not be justified by the savings that result, and we plan to deliver them to a point about 250 feet away from the plant.



SPECIAL CABLE REEL TRAILER WITH MOTOR-OPERATED HOIST AND TRACTOR

Handling of Lumber

The structure of the telephone switchboard is made up of structural steel covered with finished hardwood. The woodworking end of it properly begins with the lumber yard which is south of 26th Street. The lumber yard is divided into two main sections, the softwood yard being separated from the hardwood yard by a space of approximately 70 feet as required by insurance regulations. The manufacture of switchboards and other parts requiring lumber, demand that we keep on hand over one hundred sizes, species and grades of lumber. Some woods used are rather rare and some require storage in the yard for air drying or for the purpose of coloring.

Our hardwood lumber yard must have a capacity of more than one and one-half

million feet to accomodate this miscellaneous assortment. It is laid out with lumber piles on either side of north and south tracks. These tracks lead to the dry kiln building where the lumber is kiln-dried down to the proper moisture content. The lumber which is stored in the yard is piled in individual piles of about 8½ feet in width and up to 16 feet in height.

When the lumber is selected for kiln drying it is piled onto kiln trucks. Each kiln truck consists of two parallel channels with a small wheel at each end and three of them are set on rails which are mounted on the top of the flat car, the weight of the lumber being sufficient to hold them in place without the use of any spacer bars. The pile of lumber loaded on the three trucks makes up a movable unit. A load of lumber piled for kiln drying is about 6 ft. 10 in. in width, 16 ft. long and 9 ft. high. Sticks are placed between the boards in order to permit free passage of air up through the lumber. Two such loads are transferred on a flat car by an electric locomotive into the dry kiln building, where they are unloaded and moved into the kilns.

A 25-ton electric locomotive is used for shifting cars of lumber in both the hard and soft wood yards. This locomotive was put in operation in our plant about two years ago, having replaced an old compressed air locomotive which had been in use for about 16 years. Several attempts have been made to replace the old compressed air locomotive with an electric locomotive, but until we built our box factory and woodworking mill and transferred the softwood lumber yard south of 26th Street, we were not able to "prove in" the new type of equipment. This old air locomotive used compressed air at 1,000 pounds pressure which was piped over from our Power House. When we laid out the new lumber yards we found that a number of new charging stations would be required. We also found that with the increased load on the locomotive it frequently ran out of air at some distance from charging stations, and on such occasions it had to be towed in. The space taken up in the power house by the 1,000-lb. air compressor was wanted for other equipment. With these factors to assist us, we had no difficulty in "proving in" the more modern equipment, and the results obtained with the storage battery locomotive have been very satisfactory.

Handling of Lumber in Dry Kiln Building

We are revamping our lumber dry kilns and are changing from the progressive hot air kilns to the more modern compartment type humidity kilns. At the same time we are making changes in our methods of handling hardwood lumber. Manual labor now used for moving kiln loads of lumber will be replaced by an electric winch which will derive its source of power from the electric locomotive. While the operation of pushing the kiln loads of lumber by hand is not expensive, it is the kind of hard manual labor that the company is making every effort to eliminate.

Some new features will be found in the layout of the new kilns at the Kearny Plant. The system of piling loads and handling them will be somewhat different than it is at Hawthorne. Loads of lumber will be piled in such a way that the load will be moved in the direction of its length rather than at right angles to it, and will be mounted on four kiln trucks which will run on two tracks. We will have humidity kilns with capacity for four loads of lumber, or about one car load. All handling of kiln loads will be performed by an electric transfer car which will travel in a pit running the full length of the dry kiln building. This transfer car will be a standard type developed for this purpose, which will receive its power through a cable which will be wound or unwound on a take-up reel mounted on the transfer car. This transfer car will be equipped with a power driven winch, and will travel along the transfer track under its own power.

The lumber at both Hawthorne and Kearny will be handled between the storage area in the dry kiln building and the woodwork mill on hand trucks. Our woodwork is of such a miscellaneous nature that we cut up very few full kiln loads of lumber at one time. We have, therefore, been unable to "prove in" the use of some of the auxiliary equipment used in the large mills whose product is more uniform than ours.

Handling of Woodwork and Ironwork

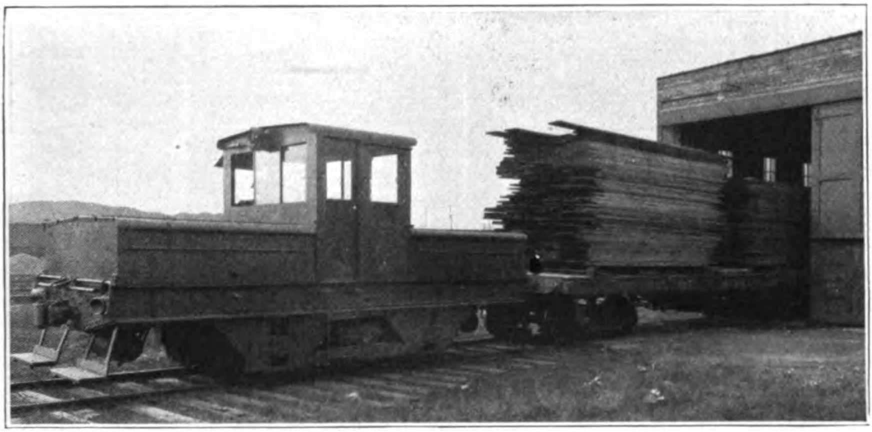
The rough mill work is performed at our hardwood mill at the 26th Street Plant and it is transferred by auto trucks to the telephone apparatus shops. It then passes through our cabinet making and wood finishing departments to the assembly where it is mounted on the steel frame works and thence to the wiring department.

In connection with the manufacture of steel frames for switchboards, I might mention that our structural steel storage is located in a building which is adjacent to a railroad track. Steel is loaded directly into storage racks through the windows of this building. The saws, shears and punch presses which are used for cutting the steel to length are located directly in front of this rack and the steel is handled directly to these machines from the rack. This system of handling steel works very successfully for our miscellaneous class of work and reduces handling to a minimum. The cut steel is loaded onto transveyor platforms and is moved on. these platforms from operation to operation until it reaches the switchboard assembly department.

A completed switchboard is transported on a special switchboard truck, which is loaded into a trailer, and it is delivered to the Merchandise Warehouse to be packed and shipped.

Handling of Softwood Lumber

During the year 1924 we used over 20 million board feet of softwood lumber for the manufacture of packing boxes and cable reels. All of this lumber was hauled an average distance of over 1,200 feet by a small electric tractor on special trailers. The softwood lumber yard is laid out with concrete runways along each row of lumber piles, and the conditions are ideal for the equipment we are using. The tractor is equipped with a special coupler and trailers can be coupled or uncoupled by the tractor operator without leaving his seat. The trailers are rubber tired to save wear and tear on the runways and they are designed to run on the rear wheels only when coupled to the tractor. The coupler on the tractor is so designed that it lifts the trailer off the supporting swivel caster, when the tractor is backed into the trailer.



HANDLING LUMBER WITH ELECTRIC LOCOMOTIVE AND SPECIAL CARS

As the tractor operator approaches the box factory he presses a button mounted on a post alongside the runway about 80 feet from the entrance. He thereby causes a motor operated Kinnear door to raise, and by the time he reaches it, running at normal speed it is raised high enough to permit him to pass through. A control is located inside the building which he operates to close the door after him. The lumber on the trailers is backed up to swing saws, and is unloaded by the sawyers as they cut the boards to length. The empty trailers are then returned to the lumber yard. This system has worked out so successfully that

we have reduced the cost of handling lumber almost thirty per cent as compared with the old lumber yard where hand methods were used, and the average trucking distance was fully three hundred feet less.

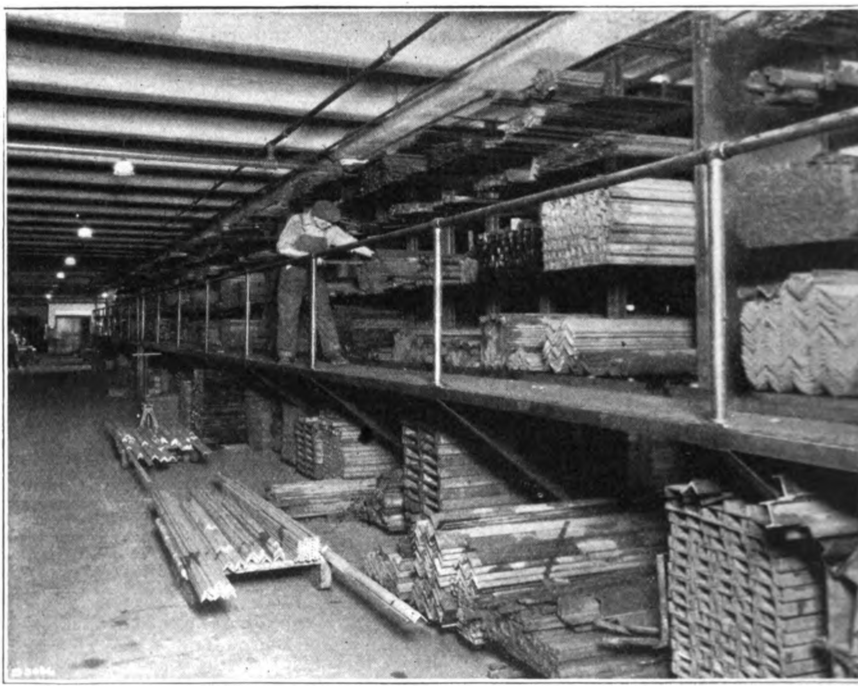
Handling in Packing and Shipping Department

Boxes are shipped from the Box Factory in cars which are unloaded in the Merchandise Building. As the boxes are unloaded a comprehensive system of conveyors elevates and distributes them onto a balcony on the second floor of the packing department. As boxes are required for packing they are sent down chutes to a gravity roller conveyor. The boxes are packed on this conveyor and pass along to the nailing machine which nails on the covers. The boxes next pass along the conveyor over scales, where they are weighed and stamped. From this point they travel down a spiral chute to the first floor, where they are loaded onto electric load-carrying trucks for delivery to cars for shipment.

Acid Handling

We have an interesting application of electric trucks in our new system for handling carboys of acid. We formerly stored acid in a space just east of our Cable Plant and unloaded the carboys by hand with a two wheeled truck which was run down an incline from the car door. The carboys were later loaded onto auto trucks and delivered to storage in the oil house of the telephone apparatus buildings from which it was drawn as required. This system required a large amount of handling and rehandling which involved considerable expense. We also had considerable breakage.

We have replaced this system and now store acid carboys on large platforms, eight carboys to a platform. The platforms are handled by an electric lift truck to the oil house and to all departments requiring acid. Space has been set aside in these departments to provide for the storage of acid in platform lots. The success of this system depends on our being able to keep the carboys on



RACKS FOR STORAGE OF STEEL NEAR THE MACHINES

the platforms, without rehandling. This system has been in operation over a year, and the cost of handling acid has been reduced one-half, and breakage has been almost eliminated.

Acid Handling in Plating Departments

The emptying of acid carboys in the acid dipping department has always been a hazardous job, and a number of complaints were received from the hospital regarding employees being burned by acid splashing or by carboys breaking. We have applied an old principle to overcome this difficulty and we now empty carboys by air pressure. A stopper has been devised with a short tube for low pressure compressed air, and a long tube extending to the bottom of the carboy. The pressure of the air on the surface of the acid forces it through the tube into the acid dipping units. The air is piped to convenient locations throughout the department, and the whole system is so convenient that there is no incentive for operators to choose the more hazardous method formerly used, as is sometimes the case where improvements are installed. This system has eliminated the hazard from this operation and we hear of few cases of acid burns. The system also reduces cost to some extent, but the safety feature is its most important advantage.

I might add that we empty barrels of paint and heavy oil by this same air displacement system.

Handling of Punch-Press Tools

One of the interesting problems which has been solved at our plant is the handling of heavy punch press tools. We have provided elevating table trucks for transporting punches and dies between the storage racks and the punch presses, and between the punch presses and the tool room. These trucks have sufficient range to accomodate the various heights of punch presses, and they have practically eliminated all manual lifting in transferring the heavy dies.

When we wish to put punches and dies into racks we bring the table truck up to a small portable elevator and transfer them with this equipment to the desired shelf. This system practically eliminates hazard in handling the tools and is justified for this reason alone. It has an additional advantage in that it has reduced the breakage of expensive tools.

Storage and Handling of Silica Sand

The number of metal parts requiring sand blasting has increased so rapidly at Hawthorne during the past few years that our consumption of silica sand has gone up by leaps and bounds. Last year we used about 14 tons of this material per day in our sand-blasting departments.

This sand has always been sold to us in bags, and the cost of bagging has been a big item of expense. In addition to this we have been forced to give up valuable building space for the storage of bags of sand.

We have a project under way for a complete handling and storage system which will enable us to receive silica sand in bulk in paper lined box cars. The cars will be unloaded with a drag scraper which will discharge the sand from the car door into a receiving hopper and a bucket conveyor will convey it to overhead storage hoppers.

Daily supply hopper will be supported outside of the building and above the sand blasting room which is on the fourth floor. Belt conveyors discharging into bucket elevators will convey the sand from the main storage hoppers up to the daily supply hoppers. The sand will be discharged by gravity through chutes in the wall of the sand blast room. We may ultimately pipe the sand to the sand blasting machines, and force it into the machine hoppers by compressed air. However, the saving which we can make with this is so small that the expense is hardly justified at this time.

Handling of Waste Sand

The disposal of spent sand from the sand blasting department is to be included with the proposal for handling new sand. A mechanical conveying system will conduct the waste sand from the cyclones and dust collectors and discharge it into a storage hopper located with its discharge spout over a railroad track. The spent sand will then be loaded directly into gondola cars.

TECHNICAL PAPERS

JOURNAL OF THE
WESTERN SOCIETY OF ENGINEERS

Volume XXX | SEPTEMBER, 1925 | Number 9

Report on Effects of Tornado of March 18, 1925

Also Suggestions In Regard to Design of Structures — By the Officers of Bridge and Structural Section Western Society of Engineers

The report presented here in three parts is the result of many weeks of study on the part of the officers of our Bridge and Structural Engineering section who were designated a special committee to visit the tornado-swept section of Southern Illinois and if possible draw up some suggestions for better building construction. The report makes no attempt to draw conclusions from obvious freaks of the storm, but does point out certain structural weaknesses that could be corrected at small cost and would add to the stability and safety of buildings. These safeguards are important in public buildings which frequently give an impression of solidity and generally become places of refuge for large numbers of people in time of storm. The report is not claimed to be the last word on this subject; it is in fact only a beginning, but one which indicates a fruitful field for continued investigation.—Editor.

PART I

ON the afternoon of March 18, 1925, the atmospheric conditions became such that a tornado formed over the southeastern part of Missouri and moved in an east-northeasterly direction across the southern part of Illinois and into Indiana. The tornado, which is the subject of this report, originated about 1 o'clock in the afternoon along the edge of the Ozark hills in Reynolds County, Missouri. It passed over sparsely settled territory until it struck Annapolis at 1:15 P.M. From there it continued to move in an almost straight path 21° north of east, across the Mississippi River, through Gorham, Murphysboro, DeSoto, Bush, West Frankfort, and Grossville, then across the Wabash River and into Griffin, Indiana. From there the storm apparently curved to the north passing through the edge of Owensville and then through Princeton, finally dying out and ending three miles southwest of Petersburg, Indiana.

The destructive path varied from one-half to one mile in width. Shortly after passing Princeton, it narrowed to one-fourth mile but continued severe for seven miles.

This tornado from the standpoint of disaster, death and destruction was the largest on record in the United States.

The number of deaths exceeded 800, while thousands were injured. The damage to property ran into millions, and the total will probably never be known. Out of the total deaths more than 600 occurred in Illinois.

The most disastrous previous storm on

NOTE: The members serving on this committee were:
Hugh E. Young, Chief Engineer, Chicago Plan Commission, Chairman.
Max L. Loewenberg, Structural Engineer, 111 W. Monroe St.
Frank A. Randall, Structural Engineer, 130 N. La Salle St.
J. B. Schaub, Engineer, I. C. R. R.
F. G. Vent, Assistant Engineer, I. C. R. R.

record in the United States, from the standpoint of deaths, occurred in Louisiana and Mississippi on September 29, 1915. In that storm 549 people lost their lives.

The Climatological Data, Illinois Section, for March says: "it can positively be stated that there was only one tornado in Illinois. The amount of property damage simply depended on what was in the path. There was no lifting and skipping commonly found with such disturbance. Topography seemed to have little effect on the storm. Within a mile on either side of the devastated path nothing was harmed."

As near as could be determined by the State meteorologists, the time of day at which the tornado hit the various points was as follows:

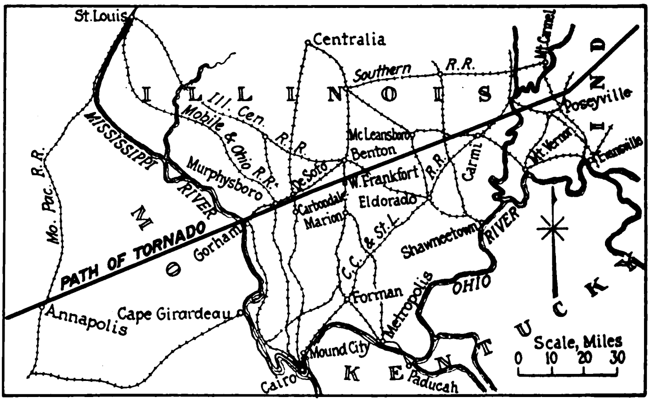
Tornado originated in western part of Reynolds County in Missouri about 1:00 P. M., and followed the path shown in View A.

Hit Annapolis, Mo.	1:15 P. M.
Hit Gorham, Ill.	2:25
Hit Murphysboro	2:34
Hit DeSoto	2:38
Hit Bush	2:45
Hit West Frankfort	2:54
Hit Parrish	3:05
Hit L. & N. R. R. west of Carmi	3:40
Hit Crossville	3:50
Hit Griffin, Ind.	4:00 to 4:05
Hit Princeton, Ind.	4:18
Died out near Porter	4:35

The times noted do not check up exactly with the scaled distances on the map, but are near enough to indicate the movement was practically uniform. The total distance traversed was about 218 miles with an average speed of about 60 miles per hour.

The Mattoon tornado of May 26, 1917, covered 293 miles with an average speed of about 40 miles per hour. The number of casualties and the destructiveness of the storm was due to its great length, unusual width, and the fact that the path was through a thickly populated territory.

As to tornadoes in general, there is considerable literature available. A great deal of it is in government reports and covers particular tornadoes. Other information of a more theoretical nature is to be found in text books on tornadoes, the atmosphere, the weather, meteorology, etc. In the preparation of this article, information has been obtained from "The Weather" by E. B. Dunn, "The Atmosphere" by Douglas Archibald, "The Tornado" by H. A. Hazen, "Meteorology" by Milham, and "Why The Weather" by C. F. Brooks.



MAP OF THE STORM PATH

The following description of the formation of a tornado gives some idea of this phenomenon of the atmosphere.

There is a constant circulation of air flowing from the equator towards the poles in the upper atmosphere and a counter-current which flows from the poles along the surface of the earth towards the equator. This movement of air north and south is due to the high

temperature at the equator and the low temperature at the poles. The warm air ascends and flows towards the poles while the colder air holds to the surface of the earth and flows towards the equator to replace the warmer air.

This phenomenon is the same as takes place in heating a house. The air in the furnace is heated, it rises through the pipes and into the rooms above. The cool air in the rooms drops to the floor, passes along the floor to the return pipe and goes down to the furnace to be heated again.

This unequal distribution of surface temperature and the resulting change in density causes a flow of air from place to place, and prevents it becoming stagnant and unhealthy.

The general circulation of air over the earth's surface is governed by the rotation of the earth. As this rotation is from west to east, it deflects air currents to the east or to the right in the northern hemisphere and to the left in the southern hemisphere. The movement of air currents in the middle latitudes is from west to east.

An area of low pressure is where the atmospheric pressure is least or where the barometer reads the lowest, into which the winds from all sides blow. The system of winds established by blowing towards the low pressure center is called the "cyclonic system" for the reason that the winds blow spirally inward and upward, with a counter clockwise movement, and when nearing the center the spiral motion becomes more pronounced.

This explains why every large storm of the atmosphere is now called a cyclone, because it is found that the air moves around and in towards a central area. In other words, a cyclone is a large disc of air moving, nearly horizontally, circulating spirally round a central area over which the barometric pressure varies from one-fifth to as much as three inches below that at its border. Cyclones range in diameter from 20 to 3000 miles.

A tornado, on the other hand, consists of a narrow column of air varying in width from 20 to 1400 feet which is rotating with immense velocity (up to 500 miles per hour) around a central shaft up which it is also ascending with a speed in some cases of 100 miles per hour. The action is very intense and concentrated. Tornadoes are common in the Mississippi Valley.

The prime cause of tornadoes appears to be a local instability of the air due to an accumulation of heat near the surface, combined with an influx of cold air from the stratum above. These together cause a rapid fall of temperature in a vertical direction.

In such a case even dry air may temporarily ascend in a narrow column and burst through the upper layers. When once this has taken place, the surrounding air rushes in to supply its place and there ensues a whirling just as in the case of water running down through a basin outlet.

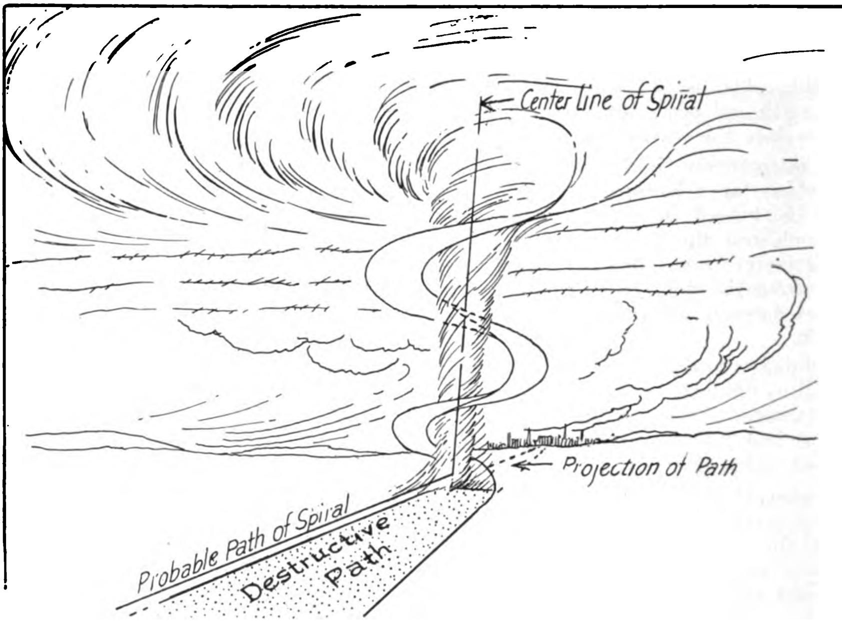
It is a well known principle that when one eddy forms inside another, the small eddy takes the direction of rotation of the larger. Since a tornado is so small and the path covered so short as compared with the thundershower which it accompanies, it is not unreasonable to think of it as an eddy. In the northern hemisphere this rotation of air is moving counter clockwise about an area of low pressure. Thus it is reasonable to believe all tornadoes in the northern hemisphere rotate counter clockwise.

After the whirling has once started, the gyrations near the center become so rapid that ultimately a funnel shaped column of highly rarefied air is produced which is marked by the appearance of a sheath of cloud or water within which is a partial vacuum. Round and up the sides of this the air ascends, flows out above, and again quietly descends over a wide area.

When the air is dry, the action cannot continue very long since the ascending air soon reduces the vertical temperature differences. Dust whirls and sand storms are consequently short lived and never of destructive violence.

When, however, the lower air is very damp as well as hot, the action can go on for a much longer time and with far greater energy.

Lieut. Finley of the U. S. Navy, made a special study of American tornadoes



SKETCH OF A THEORETICAL TORNADO FORMATION

and estimated the velocity of the wind rotating near the center of a tornado as reaching as much as 500 miles per hour and as exerting a pressure of 250 lbs. per square foot. The upward velocity is estimated to reach as much as 100 miles per hour in order to sustain the objects which it frequently does.

The central column of rarefied air by reason of its expansion is cooled below the dew point. Therefore, whatever vapour exists becomes condensed into a visible sheath. This is the cause of what are termed "waterspouts" which are only a mild form of tornadoes. In the real tornado the black funnel shaped cloud which forms a marked feature is due to the same causes.

The prevailing funnel shape, tapering downwards, of the tornado cloud is a consequence of the increased pressure of the air near the surface. Above the surface the absence of friction and the lower pressure allow the central area of rarefaction, produced by the rapidly whirling air, to extend for some space laterally. Lower down the centrifugal tendency of the rotating air is met by increased inward pressure and is thus confined to a narrower space. Outside the central core the air moves gently towards the center. When water in a basin is descending through a hole, a similar gentle flow may be observed, the rapid whirling only extending for a short distance immediately around the hole.

Even in destructive tornadoes the area of dangerous damage and violent wind is confined to comparatively narrow limits. The width of tornado paths in America ranges from 20 feet to 2 miles and averages about 1400 feet. The length of their path is usually not more than 20 miles since the forces which give rise to them, unlike those of cyclones, depend entirely on specially marked vertical gradients of temperature which seldom prevail simultaneously over large areas.

Tornadoes may be regarded as a kind of atmospheric eruption on the order of a volcanic eruption on the earth's surface. They prevail where the local conditions favor the establishment of explosive heat conditions, that is, where the geographical conditions are favorable to the facile movement of cold air from the

north alongside or above warm air from the south. Such an area exists over the flat river basins of the Mississippi, Missouri and Ohio. The states lying in these basins are those in which tornadoes are found to be most prevalent.

The general north and south trend of the mountains and hills in America favors the flow of air having such contrasted conditions, while the prevalent east and west ranges in the Old World act as preventative barriers.

The time of year most favorable to the production of tornadoes is spring and early summer, when the earth is heating up rapidly and the air above it is still cold from the effects of the preceding winter. Tornadoes usually occur in the afternoon when the accumulation of heat in the layers has reached its greatest amount. When conditions become right a half-degree increase in temperature may cause the tornado to be born.

The coincidence of earthquakes and intense cyclones or tornadoes has often been noticed. When the earth's crust is in an unstable condition, it is very probable although it has not yet been proven, that the stresses accompanying the passage of a tornado may be sufficient to initiate a quake. A drop of 2 inches in barometric pressure means that a load of about 2,000,000 tons is removed from each square mile of land. Over the neighboring sea a 10 foot rise of water commonly associated with a tropical cyclone would add about 9,000,00 tons less 2,000,000 tons for reduced air, or 7,000,000 tons per square mile of sea bottom.

Some people are possessed with the idea that a tornado has little or no chance of ever striking the same spot twice. A recent newspaper article quoted someone as having stated that not once in a thousand years would a tornado hit the same spot twice. These ideas and statements do not seem to be borne out in actual observation. A map of the Central West, prepared by the American Insurance Company of Newark, N. J., shows the paths of destructive tornadoes in that territory for the past 25 or 30 years. A glance at this map reveals the fact that many times tornadoes have hit the same spot.

A tornado is always associated with a heavy thundershower. The characteristics of the day and the weather changes which precede the coming of a tornado are the same as those which herald the coming of a violent thundershower on a hot, sultry, summer afternoon. For that reason, it is of interest to note from a map of the United States showing the average annual number of thunderstorm days, that the extreme northeast part and the west coast have very few, while Missouri and Florida range from 50 to 55.

Probably the easiest way to visualize what takes place in a tornado is to think of a spiral ramp or incline with the spiral continually turning in a counter-clockwise and upward direction, the entire body of the spiral at the same time moving in a lateral direction. The width of the spiral sweep or imagined ramp, may be anything from a very few feet up to a thousand feet or more, the latter apparently being the case in Southern Illinois.

When the sweep is very narrow it results in a storm path only a few feet wide and evidences of the twisting effect are apparent in trees twisted off the stump or out of the ground, houses picked up and partly turned on their foundations, roofs lifted off and partly or completely turned around before being deposited, and other similar devastation.

When the sweep is very wide, as was the case in Southern Illinois, the evidences of twisting are not so apparent and plentiful. In some few cases the results indicated a definite twist. Throughout most of the path the destruction appeared to be the result of a direct wind. However, in such areas there are two conclusive proofs of twisting:

1st — The velocity of the wind, in order to do the damage it did, has been conservatively estimated at 200 miles per hour or more. The actual velocity of the storm body was only 60 miles per hour, a velocity which would do comparatively little damage. It is evident the difference in velocity was derived from circular motion.

2nd — The direction of the storm travel was slightly north of east. The immediate results of the storm, such as collapsed sides of tanks, the direction of fallen trees, houses and the like, and splinters driven into trees and other objects, indicated a storm moving from south to

north. This difference can be explained only by circular motion.

Even with these explanations it would at first appear necessary for the devastation on one side to be thrown in a reverse direction. **View D,** sketch of a Theoretical Tornado Formation, illustrates how it could be possible for the spiral to act and yet not leave wreckage thrown in a reverse direction. This sketch shows the rotation in a counter clockwise direction, which is correct for the northern hemisphere, and assumes the center line of the spiral projecting to the ground and moving in a path to the left of and outside the devastated area. It is assumed the destructive wind has raised above all ground objects before it has rotated enough to throw wreckage in the reverse direction.

It seems that very few people saw any definite spiral formation, more especially where the destructive path was widest; however, in a twister of that magnitude it is conceivable that surrounding cloud banks were so heavy and hanging so low that the upper spiral formation was concealed. The State Meteorologist's reports stated that wreckage was conveyed northeast, and deposited to the north side of the storm path. This result can readily be reconciled to the sketch.

On March 28 and 29, at the suggestion of President Howson, four members of the Committee, namely, Messrs. Young, Randall, Vent, and Loewenberg, visited the devastated area. The following pages describe conditions in West Frankfort, DeSoto, and Murphysboro.

PART II

At the Chicago, Wilmington and Franklin Coal Company Orient Mine No. 2, West Frankfort, Illinois — the administration building is at the eastern end of the plant. Just west of the administration building is the store room building, and the second building from the administration building is the blacksmith and machine shop. The administration building is constructed of reinforced concrete.

There were about fifteen people in the building at the time of the storm. Several of these people with whom our committee talked, stated that the storm occurred at about 3:03 P. M., March 18, 1925. Twelve of them took refuge in the vaults and were unharmed. Three men were in the northeast room on the first floor, but were not injured, as the main force of the storm exerted itself on the southwest corner of the building. The wind blew all of the windows inward on the south and west faces of the building, and blew them outward on the north and east faces, excepting the northeast room on the first and second floors which remained intact.

FIG. 1. STEEL WATER TANK DESTROYED AT ORIENT MINE.

It is reported by Mr. O. C. Grimmett, Manager of the Mine, that one door was blown completely out of the building, also that desks and other pieces of furniture disappeared from the various rooms. The partition in the southwest corner of the building was blown down and the doors in other sections of the building on all of the floors were torn from their fastenings and some of them badly splintered. Missiles were blown through a number of walls and doors, leaving clear-cut holes through the partitions. It

FIG. 2. THE ROOF WAS TORN FROM STORE ROOM BUILDING.

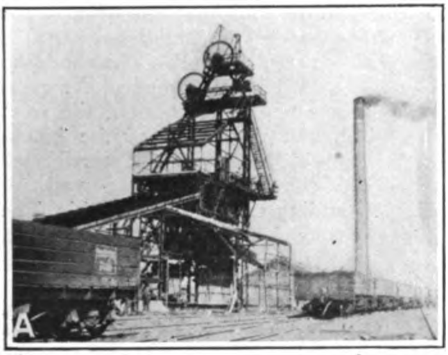


FIG. 3. TIPPLE DAMAGED BUT CONCRETE SMOKE STACK STOOD UNHARMED.

was noted that most of the steel sash in the windows held, which accounts for the fact that the interior was not damaged more severely.

The partitions were constructed of tile. The floors consist of I beams, supporting concrete floor slabs. The ceiling of the second story is constructed of metal lath, suspended from the roof structure. The skylights were blown off the building, and the flashing on the roof was damaged.

The south face of the administration building was completely covered with a gray mud, which was carried in suspension by the storm.

Mr. Grimmett reported that at first there was a little rain, which was followed by hail and then the wind. He said a Dodge roadster, which had been parked a short distance from the east front of the building, was picked up by the storm and blown a distance of about 200 feet north of the building. A Buick roadster was also blown from the north end of the building to a point about 200 feet northeast of the building, and was demolished.

Some railroad cars were standing on the railroad embankment near the administration building. The bodies of these cars were lifted from the trucks and blown in various positions on the roadbed — one being blown entirely off the bank, landing on five Fords, which had been parked at the foot of the embankment. The car landed right side up and apparently had been blown bodily from the tracks, as the embankment did not show any signs of abrasion. It is reported that four of these Fords were driven away after the car was removed.

In a number of instances extremely large and heavy objects appeared to have been lifted bodily into the air, carried a considerable distance and then deposited lightly on the ground. The local condition seemed to indicate that there was a gradual lessening of the uplifting force to the extent that there was little impact when the objects fell to the ground.

60,000-Gallon Water Tank

Fig. 1 shows the position of a 60,000-gallon water tank after collapse. This tank was located between the administration building and the railroad embankment. The tank is of the usual steel construction, circular in section, with hemispherical bottom and conical roof, supported by columns 85 feet in height, built of structural steel, and was manufactured by the Chicago Bridge and Iron Works.

The view shows the tank was intact when it landed on the ground, at which time two bottom plates were bent.

The tank was supported by four columns, which were braced with rods. The columns consisted of latticed channel sections, and were supported on concrete pedestals, being anchored to them by means of 1¾-inch diameter bolts — one bolt in each column. All four anchor bolts show tension failure. The tank was blown in a northerly direction to a position just north of the two north column foundations and midway between them. A study of the anchor bolts indicates that the anchorage on the wind-

FIG. 4. THE WIRE FENCE WAS LAID FLAT.

ward side failed in tension, and that the other bolts in addition to failure by tension indicate a slight bending. The single bolt in each column was entirely insufficient to withstand the pressure.

In another section of this report an analysis is given in regard to the failure of this tank.

All the concrete foundations were apparently in good condition. The north corner of the southeast column bearing plate was bent up at an angle of about 45°, a distance of about five inches. The bearing plate was 5/8 inch thick. The entire base of the southeast column was twisted up. The column shaft itself is in fairly good condition.

The northeast column of the tank was buckled, also twisted and buried in the ground. The base was badly bent and twisted. The anchorage bolt on the southeast column was elongated. The southwest anchor column base was bent up on the north corner the same as the southeast. On the northeast column the nut was in place on the bolt after failure.

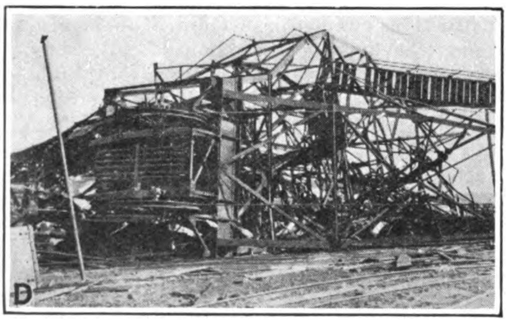


FIG. 5. WRECKAGE OF TIPPLE AT PEABODY MINE 18 WHICH FELL TO THE NORTH.

A study of the failure of a great many structures in the tornado district indicates that there must have been a terrific uplift or suction in the path of the storm.

Other Mine Structures

The store room building shown in Fig. 2 was built of brick walls, steel trusses and cement tile roof. Pure cement mortar was used in the wall construction. Several windows were blown out. A portion of the tile roof of the building fell in, and the doors were blown in.

Next to the store room building was the blacksmith and machine shop — the two shops being one building separated by a brick partition wall. This building consisted of brick walls, steel roof trusses and purlins and precast cement tile roof. The south and west wall of the blacksmith shop blew in and the north wall blew out. The east partition wall remained standing except for the gable. The roof was blown partly off the building. The wire glass windows in the part remaining were bent in.

A 20-ton locomotive crane was lifted off the tracks and laid against the wash house building, the boom of the crane lying on the roof of the wash house. This gives a good indication of the lifting force of the storm.

Fig. 3 shows the auxiliary tipple and the reinforced concrete smoke stack. A close inspection of this stack, which was directly in the path of the storm, failed to disclose any sign of failure. Time did not permit of a check on its verticality. The stack is 150 feet in height, 9 ft. 6 in. inside diameter at the base and 5 ft. at the top. It was built by J. P. Boland Construction Company of St. Louis, in 1922. The one story brick building just north of the smoke stack, known as the wash house, had the west windows blown in. Otherwise the building is in good condition. An analysis of this stack is made in another part of this report.

The siding and roof of the auxiliary hoist tipple which consisted of corrugated zinc, were blown off the building. The anchorage of the building was in good condition after the storm, and the tipple was functioning fifteen minutes later. The building was in the path of the storm, buildings on both sides of it being destroyed.

Fig. 4 shows the effect on Cyclone fence. The posts were bent due north, the position of practically all structures which were displaced by the storm, with respect to their original positions.

General devastation was wrought by the storm immediately south of the mine property. Very little remains of this one time neighborhood of West Frankfort, where formerly many of the miners lived.

The overhead conveyor was totally destroyed. The conveyor supports were mounted on concrete piers, part of which were pulled out of the ground. The en-

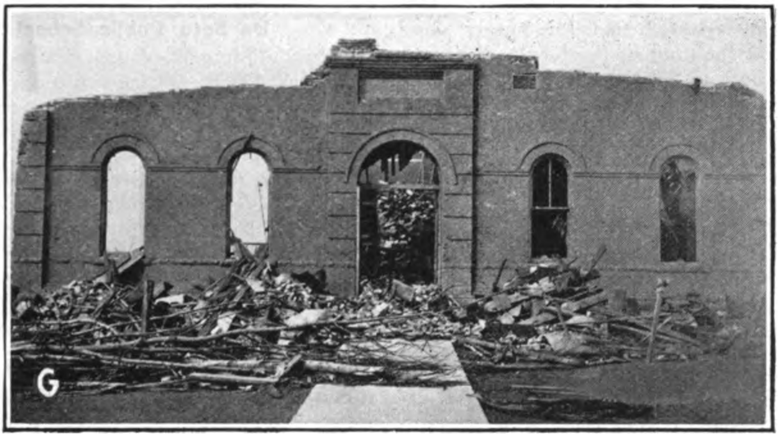


FIG. 6. RUINS OF THE DE SOTO SCHOOL WHERE 33 CHILDREN WERE KILLED.

tire structure was blown over to the north. The steel was badly twisted and a total wreck. The conveyor structure was anchored with a single bolt at each support. Many of these bolts failed in tension.

The main tipple and the re-screening building were stripped. The siding and roof, which consisted of corrugated zinc, were blown off the tipple, but it was functioning immediately after the storm had passed and few repairs were necessary.

The re-screening structure is rather narrow, and while the corrugated zinc was blown off the roof and side, the large bins presented considerable resistance to the terrific wind pressure, which exerted a great overturning pressure on the structure. The bins were filled at the time of the storm. The base plates on the leeward wide of the storm were dished under the columns as much as ¾ of an inch, and the entire diagonal bracing on the north side was twisted and bent. The entire structure was bent about one inch out of plumb. The windows were blown out of the structure. A hurried examination did not disclose any tension failure on the windward side of the structure.

The main hoist house, located immediately north of the tipple, had the roof blown off, the doors blown off, and the windows blown in. The building is of ordinary brick construction. The power transmission line, located just north of the plant, was blown down.

A pine board 1x5 inch was blown through a pine plank 2x6. The end of the board was not battered in the least, and the tongue on the board furrowed a groove in the 2x6 as though it had been done by a machine. The end of the board penetrating the 2x6 consisted of a beveled knot. The leeward side of the 2x6 is splintered. It is also cracked longitudinally.

Orient Mine No. 2 is 502 feet deep, but the force of the storm was so great that the air in the mine was reversed, and a slight commotion of the air was experienced.

Peabody Mine No. 18

Peabody Mine No. 18, located about six miles northeast of West Frankfort was practically demolished. The fury of the storm was severely felt in the mine. Air currents were reversed. The super-

FIG. 7. THIS CHURCH WAS NOT ANCHORED TO ITS FOUNDATION.

intendent reported that the hinges were blown off the door of the blacksmith shop in the bottom of the mine. The depth of the mine is 518 feet.

The wind struck the tipple structure from the southeast. The southwest pier was pulled out of the ground and hurled about 45 feet in the northeast direction. The piers were about three feet deep, about three feet square, of pyramidal shape, and in general broke at the bottom of the anchorage.

The anchorage plates were 5x$\frac{3}{8}$x10 inches in size. The anchor bolts were about 1$\frac{1}{8}$ in. in diameter. The piers were about 31 in. square on the top.

The section of the tipple columns consisted of 8x8x$\frac{3}{8}$ inch angles. The base plates were 24x24x$\frac{9}{16}$ inch. Base plates and angles were badly rusted. The base of the southwest column pulled away from the anchorage bolts. The tipple in general was in a badly rusted condition, and, we understand, was about twenty years old. The weakened condition of the lateral bracing doubtless contributed to the failure. The condition of the main members indicates a failure of the bracing.

The radial brick stack was lying in a due northerly direction. This stack is about seven feet in diameter, reinforced with concrete and rods about 12 inch centers. The boiler and engine room was a total wreck.

De Soto Public School

This building is of ordinary brick construction. The bricks were very poorly bonded together. The face brick of the east wall had practically no bond to the common brick backing. There was no anchorage of joists to walls or roof to joists. The entire building was absolutely devoid of any adequate means of bonding the various parts together. The lumber used in this building appeared to be Loblolly pine. The joists were 2x12 inches. The roof was of slate. The lower walls were 17 inches thick, and the upper walls 13 inches. The north wing of the building on the lower floor remained intact and is now being used as a school room. The upper story of this two-story brick structure was completely blown off. Thirty-three children were killed when the building collapsed. The storm hit the building blowing from the south and covered the south face of the building with a gray mud. It struck the building at about 2:45 P. M., Wednesday. March 18.

Many of the people killed in De Soto were found blown against the railroad embankment located about 500 feet north of the DeSoto Public School.

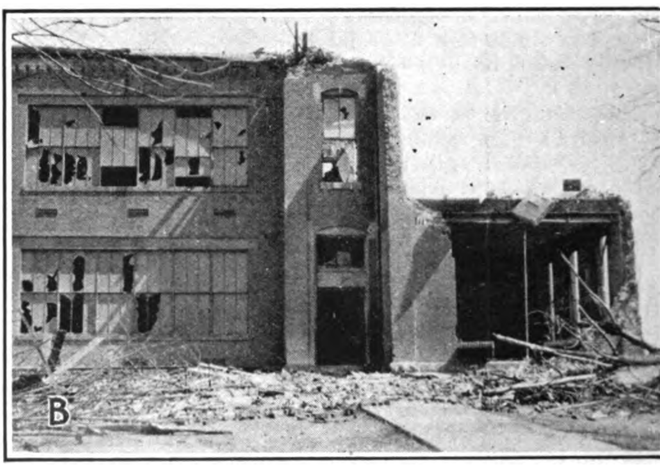


FIG. 8. THE NORTHEAST CORNER OF THE LOGAN SCHOOL WAS LEFT STANDING

Miscellaneous Reports from De Soto

The Albin residence at De Soto is of frame construction, two stories in height, and is located in the center of a circular

FIG. 9. TREES CUT OFF AT THE HOUSE TOPS NEAR LOGAN SCHOOL.

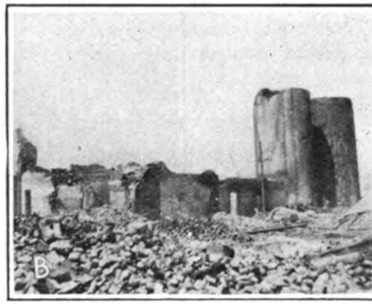


FIG. 9B. STEEL GRAIN TANKS DAMAGED BY FIRE.

row of large trees, ranging in diameter from 17 to 48 inches. The trees were located around the house at distances varying from 15 to 30 feet. The tops of the trees were broken off by the storm at about the height of the house. These white oak trees apparently broke the force of the storm to the extent that the old frame building was in good condition after the passage of the tornado. About the only damage done was the breaking of glass in the south and west windows, which were blown in. Much of the wall paper was blown loose from the plaster. A barn located a short distance southeast of the house was demolished. Very little damage was done to a house located a short distance north of this house, between the Albin home and the school house. The storm moved through DeSoto and West Frankfort in the direction north 40° east.

Mr. Doppert of the Division of Sanitary Engineering at Springfield, Ill., who had charge of the post-tornado sanitation work in Jackson County, stated that the storm hit Murphysboro about 2:35 P. M., and that the violence of the storm seemed to last about a minute. Mr. Doppert also reported the time of the storm at Bush, 2:45 P. M., West Frankfort, 3:02 P. M., and at Griffin, 4:03 P. M., — the speed of the storm being about 60 miles per hour. Observers at DeSoto said that when the storm approached a heavy rumbling was heard which sounded like many freight trains.

Fig. 7 shows the damage to the church located about one mile south of Murphysboro. The building was moved twenty feet due east and was leaning to the east. It was picked up off the concrete foundations and moved over bodily. No anchorage had been provided in the construction of this building, and the foundation consisted of tile blocks laid on concrete walls. The church was located about one mile from the tornado zone proper. A house located just north of the church was not damaged, and no evidence of damage could be seen in any of the buildings near the church. Windows on the east side of the church were not broken. The front of the church was blown across the road to the east, a distance of about 50 feet. The wind was

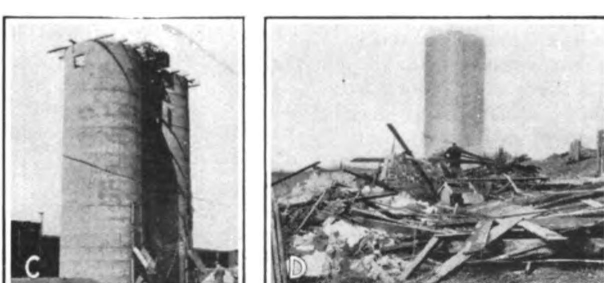


FIG. 10. CONCRETE COAL POCKETS AND SILOS UNDAMAGED BUT SURROUNDING BUILDINGS DESTROYED.

FIG. 11. THE M. & O. R. R. YARDS AT MURPHYSBORO AFTER THE STORM.

blowing due east. One window on the west side was blown out. Most of the wall paper was blown off the walls. A small brick chimney with a sheet metal stack remained in position after the storm. This stack was anchored by means of small guy wires. The church was about 15 years old. Another church about one-half mile northwest of this particular church was also blown to the east.

Damage at Murphysboro

Sixty percent of the area of Murphysboro was demolished, covering an area of six square miles and comprising 151 blocks. About forty blocks were burned.

An interesting example was a two story bakery constructed of plain concrete. The building is about 45 feet long and 24 feet wide. The upper wall was six inches thick and the lower wall seven inches. First story ceiling and walls are intact. The upper story was blown away. The concrete was of poor grade, pilasters 3x13 in. located every ten feet. The upper story was blown to the north. The only reinforcement noted in the structure consisted of mesh. The second floor had 2x12 in. floor joists, which were apparently strong enough to hold the debris blown in from the upper story.

Fig. 8 shows the wreck of the Logan School House, a two story brick structure of ordinary construction, having wooden floors. The northeast room of the second floor was not damaged, except for small holes and broken windows. The windows were blown outward. There was absolute lack of bond between floors and walls. An inspection of the brick work of the walls showed 16 rows of brick without any bonding. Inspection did not disclose any ties in the building construction. The principal effect of the storm on this structure, as in most instances, was on the south and west sides of the building. As mentioned above, the northeast corner room was not seriously damaged as in the case of the lower northeast room in the administration building of the Chicago, Wilmington and Franklin Coal Company.

The utter collapse of the Logan School is undoubtedly due to the absence of bond between the floors and walls, pilasters, lack of bracing, anchorage of roof, etc.

Fig. 9 was taken looking north from the Logan School, and shows the action of the storm in cutting off the tree tops at about the elevation of the tops of houses. It also shows the lack of basements in the houses, and also the poor character of the building foundations, which presented very little resistance to the force of the tornado.

Here a 1x8 in. board was blown into a maple tree. The plank was pointed due north and was not shattered at the end. Its penetration in the tree was about five inches in a horizontal direction, and it was held sufficiently rigid to support the weight of a man hanging on the end of it without displacement. It struck the tree about eight feet from the ground, the flat side of the board being in a horizontal position. The tree was located in an open space in line with several other trees.

The storm did some damage to two steel grain tanks. These tanks are 60 feet high and were built of twelve rows of steel plates each five feet wide. The diameter is approximately 24 feet. The south side of the south tank was crushed. The north tank was practically unin-

jured. At the time of the storm the south bin held wheat and the north one held corn. The tanks were located at the south edge of the Mobile and Ohio Railroad yards, and in the center of the devastated area of Murphysboro.

The two tanks were joined by a wooden building which extended in height to about the middle of the tank. When this structure was burned, it apparently heated the plates of the tank to the extent that they buckled. The grain in the tanks was set on fire and was still burning on March 29. The tanks were estimated to be about twenty years old. The plates of the south tank were pulled out of the foundations about ½ inch, indicating a tremendous overturning force. The south side of the north tank was loosened from the foundations. The roof on both tanks was torn off.

An idea of the force of the storm can be gained from the condition of the building near the tanks, which was first destroyed by the cyclone and then burned. At the time of the inspection trip the ruins were being searched for the bodies of three people who had been trapped in the building at the time of the storm. Fig. 9B shows the condition of the tanks at the time of this inspection.

Fig. 10C shows the reinforced concrete coal pockets, located a short distance north of the steel grain tanks. The height of these concrete pockets is 40 feet, diameter 12 feet, They were built in two sections. Inspection showed that the tanks were apparently undamaged. They were located in the central portion of the path of the tornado. The area on both sides was devastated. The tanks were built on 15 foot centers, having a space of three feet between them. The timber work between the pockets still remained in place.

The buildings east of the Mobile and Ohio right of way were totally destroyed. While the party was making an inspection of the tanks they were surprised suddenly to hear music coming from the midst of the debris, and upon investigation discovered two negro boys, one of whom was very earnestly playing on what remained of a piano.

The devastated area of Murphysboro covered a section one mile long and two miles wide. Fig. 11 is looking due north in the Mobile & Ohio yards at Murphysboro, which were completely destroyed by the tornado, with a loss of about $2,000,000 to the shops. After the passage of the tornado, fire added to the complete destruction of these shops and yard facilities.

The cars in general were lying in a position with their axes about 10° east of south. The west and south sides of the cars and all other structures in this area were covered with mud. All the locomotives in the yards remained in an upright position, but were very seriously damaged by the storm and flying debris.

Fig. 12 shows the damage to the Longfellow School, Murphysboro, looking northwest. The building is of ordinary brick construction, two stories in height, having 21-inch brick walls on the first floor and 17-inch walls on the second

FIG. 12. THE LONGFELLOW SCHOOOL WHERE 17 CHILDREN MET DEATH.

floor. The interior walls remained standing. These were substantial brick walls of vault construction, having arched openings. The walls around the stair wells also remained standing. All basement walls remained intact. All rooms on the second floor were demolished, except the two at the center of the building, which were braced by the inside walls. A room on the first floor, northwest corner, had the north wall and west windows blown out. The only rooms on the first floor which were demolished, were in the southwest wing. The upper story was practically all gone. The joists had no anchorage. The small trees on the lot fronting the building were bent in a northeast direction. Both floors on the west side were blown in. The rooms structure, the east and west wings having been added recently. The gymnasium was located in the west wing and was enclosed by high walls. The roof was supported on steel trusses. The walls above the floor in the gymnasium were completely demolished except for the lower part of the pier at the southwest corner.

This view is taken from the southwest corner of the gymnasium. The east and west walls of the gymnasium carried the roof trusses without pilasters. The trusses were anchored into a small block of concrete which is shown on the succeeding view. The trusses were blown about twenty feet to the east. At the right may be seen the repairs which have been made over the wrecked central portion.

FIG. 13. WEST WING OF THE MURPHYSBORO HIGH SCHOOL LOOKING FROM THE SOUTHWEST.

on the south, north, and east side of the first floor remained standing. About seventeen children were killed at the time the building was demolished.

The committee saw a hard pine splinter that was driven through a live poplar tree, due north direction, about a half block south of the high school. The stick was about 2 inches by 1½ inches and the tree about 18 inches in diameter. The tree was located in the rear of a yard about 50 feet north of a house which was undamaged.

High School, Murphysboro

Fig. 13 shows the south entrances to the west wing of the Murphysboro High School, a building one block in length, the central portion of which was an older

Fig. 14 shows the north end of the gymnasium where one roof truss framing into walls of the main building remained in place. The clocks throughout the building were connected to a central master clock and all stopped at 2:35 P. M.

Fig. 15 shows the ends of the roof trusses and the concrete anchorage which was torn out of the wall and remained fastened to the trusses.

Fig. 16 shows the Baptist Church at Murphysboro, which had been not quite completed at the time of the tornado. We were informed that a funeral was being held at the church at the time the storm took place.

The concrete silo shown in Fig. 10D

owned by C. H. Clay and located on West Clay Street, Murphysboro, was not damaged by the tornado. The debris in the foreground is what remained of a brick barn.

Another concrete silo was undamaged but a wholesale feed barn near it was demolished.

No damage was done to a monolithic concrete garage which was 50 feet to the leeward of a two story brick plant which was wrecked.

Fig. 17 shows the Brown Shoe Factory No. 7 at Murphysboro. This building was not in the main path of the storm, although you will note that the roof was taken off. The concrete stack is undamaged.

Fig. 18 shows the Illinois Central Railroad bridge over the Big Muddy River south of Ziegler, Illinois. The total weight of structure was slightly over 100 tons. The far end, at which the derrick is working, was moved six feet eastward or to the right, as you view the structure, the pedestal hanging just over the pier. The south end of the bridge, in the portal of which a group of men can be seen, was moved 21 inches. The entire structure was moved northward eight inches. This is a through pin span 158 feet, 6 inches long. In the immediate foreground, just beyond the barrels, may be seen the foundation of the pump house, which was completely blown away. Two upright boilers were picked up and dropped into the pit.

The pumper's dwelling in the direct path of the storm was undamaged, except for one broken window. It was protected by the heavy growth of timber.

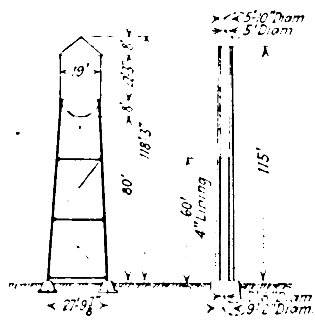
PART III

Probably the best data for determining the wind pressure per square foot exerted upon a structure in the tornado, can be obtained from the effect of the wind upon the steel water tank and the adjacent concrete chimney of Orient Mine No. 2, of the Chicago, Wilmington and Franklin Coal Company at West Frankfort, Ill.

View E is a drawing of the steel tank and a concrete chimney.

This was a hemispherical-bottom steel tank of 60,000 gallons capacity, built by the Chicago Bridge and Iron Company and of the following dimensions:

From the top of the concrete pedestals to the under side of the bottom was 80 ft. 0 in. and to the balcony was 88 ft. 0 in. From the balcony to the eaves was 22 ft. 3 in. and from the eaves to the peak of the conical roof was 8 ft. 0 in., making the total height from the top of the pedestals to the peak of the roof 118 ft. 3 in. The tank was supported by four steel columns riveted to the tank, which was 19 ft. 0 in. in diameter, and spreading to the concrete pedestals which were 27 ft. 9⅞ in. center to center in north and south and east and west directions. The steel columns were secured to the pedestals with one 1¾ in. diameter anchor bolt to each column and the



anchor bolts were carried 5 ft. 0 in. into the pedestals with anchor plates at their lower ends. The pedestals were 3 ft. 6 in. square at the top and battered to 7 ft. 0 in. square at the top of the footing course, which was 8 ft. 0 in. square and 1 ft. 0 in. thick with the bottom of the footings 5 ft. 0 in. below the ground line and the top of the pedestals 1 ft. 0 in. above the ground line, making the total height from the top of the pedestals to the bottom of the footings 6 ft. 0 in.

A steel water column of ¼ in. metal extended from the bottom of the tank to a center concrete pedestal below. The tank was 5/16 in. metal in the lower section and ¼ in. in the three upper sections with ¼ in. hemispherical bottom and ⅛ in. steel roof. The two upper sections of the columns were built of 2 12-in. channels 20.5 pounds. The lower section of the columns was built up of 2 12-in. channels, 25 pounds. Cross struts were 2 7-in. channels 9¾ pounds, and 2 6-in. channels 8 pounds, with cross bracing of 1⅛ in. diameter rods.

The tank was proportioned for a wind pressure of 50 pounds per square foot with 6/10 of the circular tank projection taken as an equivalent flat wind surface.

The total estimated weight of the empty tank, the columns, bracing and water column was 75,000 pounds. The total projected area of the tank with hemispherical bottom and coned roof was 575 square feet and assuming 6/10 of this as an equivalent flat surface acted upon by the wind, we obtain 345 square feet of equivalent flat wind surface with its center of gravity 99 feet above the top of the pedestals.

Assuming the columns as presenting one square foot of flat wind surface each per foot of height, the cross struts which divide the height into three panels at 6 sq. in. each, the diagonal at 1 sq. in. each, and the circular water column at 15 sq. in. we obtain 500 square feet of flat surface exposed to the wind, its center of gravity 40 feet above the top of pedestals, assuming the wind to strike all columns and bracing.

With the tank empty, the resistance to a horizontal wind pressure is the resistance offered by the anchor bolts added to the resistance offered by the total weight of the tank and tower upon the pedestals.

Equating the wind moment to the resisting moment, it was found that a wind pressure of 48 pounds per square foot on the empty tank would cause a stress of 16,000 pounds per square inch in the anchor bolts.

It will be noted here that although the anchor bolts were figured for a safe working stress of 16,000 pounds per square inch with a factor of safety of 3½ on their ultimate strength of 56,000 pounds per square inch, the structure will not carry a wind pressure of 3½ x 48 or 168 pounds per square foot. This result would be secured by dividing the resisting moment of the weight of the tank by the desired factor of safety.

The ultimate resisting moment equated with the wind moment results in a wind load of 120 pounds per square foot, which is only 2.5 times the wind pressure that causes a unit stress of 16,000 in the anchor bolts.

With the tank full of water, the resistance to a horizontal wind pressure is the resistance offered by the anchor bolts added to the resistance offered by the total weight of the tank and tower with the weight of the water upon the pedestals, the weight of the water being 500,000 pounds.

Equating the ultimate resisting moment with the tank full of water with the wind moment, we find the corresponding wind pressure per square foot to be 250 lb.

An investigation of the diagonal bracing rods indicated that they probably failed first, as they were only capable of taking a wind pressure of about 110 lb. per square foot on the structure, with the

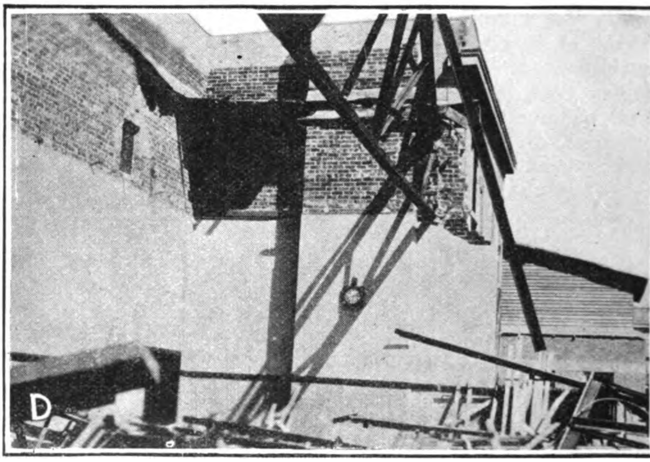


FIG. 14. ONE ROOF TRUSS WAS LEFT HANGING TO THE WALLS.

material stressed to its ultimate strength, assuming an ultimate value of the rods to be 56,000 lb. per square inch.

Calculation made for the northeast column showed that if the bracing in the lower panel failed first, this section of the column would have easily failed under the excessive horizontal wind pressure exerted on the tank.

The lower section of the northeast column had an area of about 15 square inches, and was capable of resisting in bending, a horizontal wind pressure on the structure of only 11 lb. per square foot, in addition to the axial load due to the dead load of the tank and wind pressure acting on the structure as a whole, the horizontal shearing force of the entire wind pressure under this condition being resisted by the four columns in bending.

An analysis was also made of the concrete chimney adjacent to the tank, which had the following demensions:

Height of chimney above foundation	117 ft.
Total height including foundation	121 ft.
Outside diameter at foundation	9 ft. 4 in.
Inside diameter at top	5 ft. 0 in.
Thickness of wall at base	10 in.
Thickness of wall at top	5 in.
Height of lining above foundation	60 ft.
Thickness of lining	4 in.
Depth of foundation below grade	6 ft.
Width of octagonal foundation	18 ft.
Thickness of foundation	4 ft.
Size of breeching opening	3 ft. 6 in. x 6 ft. 0 in.

The foundation was composed of 1:3:5 concrete, reinforced with 64 ¾-in. round bars in four belts.

The concrete in the chimney was of 1:2:3 mix. The vertical reinforcement at the base was 35 ⅞-in. round bars, decreasing to 10 ½-in. round bars at the top, all high-carbon steel. The horizontal reinforcement was ½-in. round bar spaced 12 in. centers, 2 in. from outside of stack. The lap of vertical rods was 40 diameters, and of horizontal rods, 24 inches.

Investigation of the wind pressure which the chimney would be capable of sustaining, assuming 6/10 of the projected diameter as an equivalent flat surface against the wind, shows that the chimney would stand under a horizontal wind pressure of 206 pounds per square foot.

This chimney was designed and built by the John V. Boland Construction Company, of St. Louis. The following is quoted from a letter from this company.

"In addition to the chimney at the West Frankfort mine we had a concrete chimney of less diameter and greater height at the Brown Shoe Company,

FIG. 15. END OF ROOF TRUSSES WHICH WERE TORN FROM THE WALLS SUPPORTING THEM.

Murphysboro, Illinois, where the entire west end of the factory was destroyed with no damage to the chimney; one for the Illinois Central Railway Company, Carbondale, Illinois; two for the Peabody Coal Company; and one for the Nason Coal Company, Nason, Illinois, which is a 10 ft. 0 in. x 200 ft. 0 in. chimney; all withstood the storm."

A brief review of the history of tornadoes in the cyclone belt does not disclose any concerted action towards the adoption of preventive means against

their destructiveness. Having in mind the old saying "To profit by past experience is noble progress," the committee has endeavored to gather all of the information possible to form a basis for recommendations, which it is believed will contribute to the public safety in the districts affected by tornadoes.

The committee has held an open mind in dealing with the subject, the attitude having been taken that every factor should be given consideration. The search for the underlying conditions has been made as thorough as time has permitted, and the position is taken that it is poor policy to economize in vital yet inexpensive details of construction. For instance, it is obvious that if the difference between a mass of wreckage and an undamaged structure is a bolt, two bolts should be used in a similar structure built in a tornado district, if they would insure against destruction.

The investigation did not indicate any condition of complete vacuum or a bursting pressure of 2000 lbs. per sq. ft. But there is sufficient evidence to warrant a conclusion that in the path of the tornado there exists an unusually low pressure.

After considering these features, it is concluded that in respect to such extreme conditions, recommendations are out of order.

However, in respect to a broad path type of tornado like the one in Southern Illinois, evidence was found supporting conclusions that most of the damage was caused by a direct force, rather than a vacuum and explosive force, and it is deemed proper to draw specific conclusions and to make limited recommendations.

This direct force is in reality a resultant force and consequently varies in intensity and direction. The field inspection indicated a surprisingly lax manner of construction; very markedly so for a tornado zone. Apparently little or no thought was given to anchorage details. In most cases there were no ties between floors and walls, roofs and walls, joists and walls, sills and foundation walls, and even face brick was laid up without even usual bonding to the common brick backing.

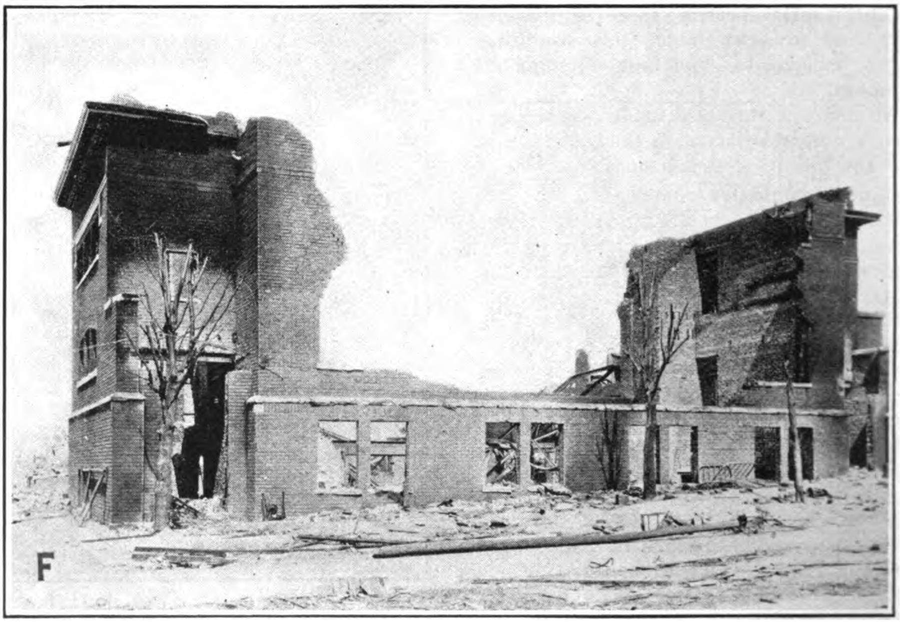


FIG. 16. RUINS OF THE BAPTIST CHURCH WHERE A FUNERAL WAS BEING HELD AT THE TIME THE STORM STRUCK IT.

An analysis of the facts indicates that the damage caused by a tornado can be divided into three classifications:

1st — Damage due to initial failure of the structure as a result of pressure.

2nd — Damage due to flying debris being driven against the structure or deposited on the structure.

3rd — Damage due to fire.

The fires originate from the fires in the heating plants and cook stoves of the structures demolished. The only known method of preventing such fires is to build all structures of fire resistant materials. This type of construction is highly desirable from other standpoints. It is a type of construction that is strongly recommended and should by all means be used in every case where possible.

The damage due to flying debris would be reduced to a minimum if the damage due to direct pressure could be overcome. In other words, without failure of structures there would be much less debris in the air. A solution of this problem would also practically eliminate damage due to fire.

In order to analyze more fully the problem and to give practical recommendations, a physical classification of structures has been made. The classification is as follows:

1st — Frame construction.

2nd — Ordinary construction, that is, brick walls, frame joists and girders, fire resistant roof.

3rd — Mill type or slow burning construction.

4th — Fireproof construction.

The order of this classification is the reverse of that which is most desirable and most highly recommended. However, it is the order of most frequent occurrence and in the order needing most careful consideration.

To the above classification also should be added:

5th — Miscellaneous structures.

The economic conditions generally prevailing in the tornado zone, make the use of timber and similar structural materials almost imperative.. Nevertheless, the builder in a tornado zone should bear in mind the need of construction to resist excessive wind pressures the same as a builder in a northern climate builds to resist severe cold.

Certain simple features, such as bolting the sills to the foundations, securely anchoring the plates, joists, studs, rafters, etc., as well as tieing the corners adds an inappreciable amount to the total cost of even the cheapest type of structure. Such added precaution reduces the liability of damage from ordinary windstorms and may even resist the forces of less intensity along the edges of a tornado. The saving due to even such minor precautions would probably run into a startling figure in a tornado of the extent of the recent southern Illinois type.

The cheap frame house, of the type commonly set on posts in the warmer climates, should at least be set on concrete piers. These piers will not only serve as anchorage but almost justify the slight additional expense, by saving in maintenance. The house sleepers or sills should be mitered and securely anchored to these piers. The larger the piers the better, in fact a continuous wall would be

FIG. 17. ROOF TAKEN OFF THE BROWN SHOE FACTORY BUT CONCRETE STACK AND WOODEN WATER TANK WERE UNHARMED.

most desirable. If only piers are used, the space between them should be closed. This will resist the wind tending to get under and to lift the building.

A next step that would add but little to the total cost would be to extend anchors from the concrete piers up between the studs and connecting to the plate or even to the roof framing. Such anchors at frequent intervals would supplement the usual more or less casual nailing of the studs to sills and plates. Strap iron ties should be used to secure the rafters to the plates. In all cases studs should run continuous from the sill to the rafter plates.

The next and a none less vital feature

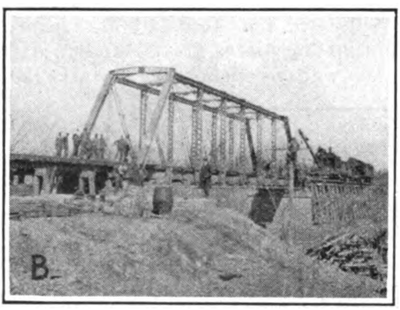


FIG. 18. I. C. R. R. BRIDGE WHICH WAS MOVED OFF ITS FOUNDATIONS.

to be given special consideration is that of bracing. The average builder considers the nailing of sheathing and siding on to one side of a row of studs and laths to be coated with plaster on the other side, as a rigid system of bracing. It is true this serves well, but can never compare with a systematic and well planned system of bracing.

In walls that are not cut by window or door openings, the bracing should extend diagonally from one corner of the wall to the opposite side, in both directions This may be accomplished by bridging between the studs, by tie rods or bolts or by tie straps. The straps may be made lath thickness and securely nailed to the face of the studs. This method of bracing applies to interior partition walls as well as to exterior walls. The designer and builder should bear in mind the necessity of having vital points, like brace reaction points, partition and side walls and the like, securely attached.

In cases where openings cut the walls, the bracing will of necessity be in knee brace form or like tower bracing at the sides of the openings.

The value of inside partitions as a system of bracing cannot be overestimated, provided the loads are properly conveyed into the outer walls and into substantial footings.

In order to improve on this type of construction, from the standpoint of safety, a small cellar, made of concrete and properly reinforced, may be built. This may be only a small room and serve as a furnace or heater room, or as a fruit room.

An advantage in having the heater room so built is the protection against fires. The chimney should be so built that removal of the upper part would not directly affect the furnace fire.

If the room is to be used as a store room or fruit room, it should be designed accordingly. A fruit room requires certain ventilation and draft control for the temperature regulation.

In any event, it would be well to keep certain tools in the room for emergency use.

The next improvement and one most highly recommended is a basement under the entire house, constructed of concrete and having a reinforced concrete floor above for the building's first floor.

A basement so constructed would serve as temporary living quarters after a disaster. In some localities, it might be well even to go so far as to recommend such basements, probably English style, to be constructed first and occupied until such time as the owner would be in a position to complete his home. A type of architecture might well be developed along the Spanish style, suitable for tornado zones. Studies along that line would tend to eliminate projecting cornices, overhanging eaves, and similar features that act as wind pockets.

What is termed ordinary construction, that is buildings having concrete foundations, brick walls and timber floor and roof construction, is most commonly used for commercial and industrial as well as small community buildings. It was this type of structure that caused the largest loss of life in the recent tornado.

In general appearance it is durable and substantial, and most people feel it is a type of structure suitable for refuge. When it fails, the brick walls crumble and fall in heaps crushing the occupants.

The first feature to be given special consideration in this type of structure is the brick wall. Naturally, the wall must be set on a good substantial foundation. The foundation should be amply wide to give full bearing to the wall, and should be designed to take safely not only the direct load, but also stress due to eccentric load or overturning tendency.

The brick wall should be fully reinforced with pilasters. Even single story walls should be so reinforced. The pilasters should be not less than 17 inches in thickness. The width of the pilasters should be not less than one-eighth their spacing. Special provision should be made for unusual story heights and long tree-standing walls.

Another vital point in connection with the wall is thorough bonding. This is an especially vital feature in the case of walls having face brick surfaces. Header courses should be laid in at least every fourth course.

In the construction of this type, it is very difficult to build in very many ties and braces. For that reason, special consideration should be given to cross walls, stair well walls, elevator enclosures and the like. An interior wall should be built and securely bonded to other walls at every point offering the opportunity. In the devastated area, walls of this nature were found to have served to a good advantage. The use of brick dividing and partition walls instead of tile or frame partitions may serve to save the structure. In all cases, brick walls should be laid up in cement mortar.

The anchoring of columns, girders, joists and roof construction is of vital importance. The field inspection indicated a gross negligence in connection with such details.

In addition to the foregoing features, the boiler room, at least, should be of concrete construction with a reinforced concrete slab above. A much better feature is to have the entire first floor, over the basement, of reinforced concrete construction and securely anchored to the foundation walls.

Since this type of structure is frequently used for store buildings, factory buildings, small community schools, meeting halls, and churches where many people are likely to be congregated, the basement would readily lend itself to use as a storm cellar. Suitable means of entrance,

FIG. 19. THE AUTHORS OF THIS REPORT EXAMINING A 1x5 INCH BOARD WHICH WAS DRIVEN THROUGH A 2x6 PLANK.

with a substantial iron or heavy door, could easily be provided. The windows should be fitted with steel sash and wire glass.

In the mill, or slow burning type of construction, the foregoing precautions as to foundations, pilasters, anchorage and the like should be carefully considered in designing.

This type of structure is in general more rigid than ordinary construction. However, it is commonly used only in larger structures. In this type of construction, it is certainly justifiable to have the basement and the first floor slab of reinforced concrete, securely anchored to the foundation walls.

All columns should be securely tied together and at the bottom anchored to the footing. Girders in all cases should be anchored continuously from wall to wall and into the walls, and should also be securely anchored to columns. Every other line of joists should be anchored together and into the walls. The roof construction should be anchored in a similar manner.

The fireproof type of construction should be used in the construction of all public buildings, such as court houses, city halls, schools for cities and districts, and similar structures.

This type of construction divides into two classes, namely, "wall bearing" and "skeleton." Skeleton construction, properly designed, will undoubtedly resist a severe storm. Wall bearing construction should receive special consideration in line with the foregoing recommendations. The designer should bear in mind the possibility of abnormal loads and provide ties, bracing, anchors, etc., accordingly.

This type of construction lends itself readily to a system of ties from roof to foundation. Even in the wall bearing type, a slight additional expense would be justified to run reinforced concrete piers from roof to footing as a tie to make the structure a unit.

Miscellaneous structures such as tanks, water towers, stacks, silos, tipples and the like are comparatively expensive structures. Liberal wind bracing and anchorage add only a small percentage to the cost.

Such structures are usually in open, exposed and often elevated localities. The designer and builder should bear these features in mind. The arbitrary addition of a small percentage to anchor bolt areas, and the placing of extra rivets in the bracing connections are negligible items of expense that may save the structure.

In conclusion, the committee further recommends in areas subject to tornadoes, that a designing wind pressure of 65 pounds per square foot be used with a factor of safety of four; that the weight of the structure be divided by the factor of safety of four before entering the weight into the calculations for stability; that special consideration be given to anchorage and wind bracing details of construction; and that normal deterioration of anchors and bracing should be considered.

DISCUSSION

Prof. Provine: A committee, consisting of M. S. Ketcham, A. N. Talbot, C. C. Williams and the speaker, from the University of Illinois, visited this district.

It has been said that when you see a tornado coming, the safest place is to run out of doors, lie flat on the ground and wait until it blows over. My observation is that I would rather be killed sitting in my own sitting room than to go outside and have something hit me in the back and kill me out in the yard. Judging from the debris which was scattered all over the territory within the limits of this storm, there is no such thing as a safe place, with the methods of construction that were used in this territory.

It has been said that if you see a tornado coming that if you will run at least fifty yards due North, you will get out of the zone. Where is the man who is going to stop to take a sight on the tornado and then be sure to step off the distance correctly in order to reach that safety zone?

Our committee from the University has not prepared its formal report. We have had informal discussions. The report is in process of preparation. But

we would repeat, if I should take the time, the findings of your own committee.

Perhaps one or two observations of ours will supplement those that have been given. One is, in the case of large auditoriums or large rooms, where the height and length of the wall, makes them particularly susceptible to wind pressure, and without lateral support they are sometimes easily overturned. The question of supporting the roof for these rooms for the safety of the human beings within, demands that all such roof trusses should be supported on steel columns firmly anchored to the foundation; that these trusses and columns should be rigidly connected by knee braces or some other form of rigid connection. These trusses should be fastened together laterally by a rigid system of bracing. This is very well emphasized by the failure of the trusses over this auditorium in the Murphysboro High School. From other observations in public buildings and school houses, where people assemble in great numbers, would it not justify the construction of corridors of extra heavy construction to provide places of refuge for the people within?

In the Murphysboro High School we talked to several teachers. One said that they were in one of these large wings which was blown down. She, for some unknown reason, anticipated something of an unusual nature, and took her entire class of 25 students into the corridor. Within a few seconds the room was demolished. The students were safe.

I don't know whether the public will stand for any recommendations regarding the extra thickness of walls and the concrete construction for walls and ceilings for corridors, but certainly in a territory in which several hundred lives were lost isn't it worth while for us to give consideration to the saving of a life? It is a question of economics, to be sure. A tornado will not hit twice in the same place so some people say, "Is it going to justify me, as an owner of a building, to put in a few hundred dollars extra in order to provide this safety, which the building may never be called upon to exert?"

We feel, however, that the public justifies and demands this additional safety.

In all of this investigation there were freaks showed up. It seemed that nature wasn't quite consistent in the way it blew down things and left things standing. In addition to those things which were shown there was the water tank of the M. & O. Railroad, a wooden tank, on wooden supports, in the path of the storm, which remained undamaged. Immediately across the street was the M. & O. Station, which blew down and burned. There was no evidence left even of the foundation. We could see the charred remains of what used to be a building. All around this territory the buildings have been razed. One of those freaks of nature! One side of the tank, had a large splinter driven into it. There were dents, some of the staves were pushed slightly out of line. At the time we were there—within a day or two after your committee visited this territory—the tank was full of water and not leaking more than the usual railroad tank. At the time we were there the raise spout was on. The question has arisen as to whether or not it was the original spout. As to that, of course, we could not say, but, judging from the dents in the spout on the windward side, it was.

John A. Garcia, M. W. S. E.: It so happens that this tornado had a rather peculiar interest for me, because it started at De Soto, went on through Murphysboro and West Frankfort and took a final crack at Mine 18, and some 18 years ago I started in Illinois Coal Mining at De Soto, went on up through Murphysboro, West Frankfort and Ziegler and wound up at Mine 18. (Laughter). Mr. Andrews Allen and myself built Mine 18 about 17 years ago. He designed and built the tipple and I dug the hole and built the rest of the plant. It was totally destroyed, his tipple and my buildings, so I guess we are fifty-fifty on that part of it. (Laughter). We joined up after that mine was finished, and have been busy the last couple of years at Orient No. 2, and we haven't learned much in the 18 years as to how to design against a cyclone or a tornado.

At No. 18 we built everything of reinforced concrete, brick and steel and when I was there after the tornado the

only thing that was left was a wooden shanty. (Laughter). Now Orient Mine was not designed against a cyclone; we just don't know how. The only thing that was built, so far as I know, against a tornado was the Cyclone Fence, and it was a total loss. The powder house was made of concrete blocks, was rather a squatty looking structure, only ten feet high and very solid. It totally disappeared and all the dynamite and powder stacked up nicely on the inside was not disturbed.

The wash house had 12-inch walls, pilasters, steel trusses and Federal Tile Roof. The tile was nicely lifted off and all of the miners' clothes that were hung on hooks were hanging there right after the storm.

One interesting thing though was the effect of the wind on the re-screener, quite a large building, built more or less on stilts, and very well framed and braced against high winds. There were some 10 men working on the inside of that structure when the storm hit, and the superintendent told me that he felt the whole structure going, as he jumped into a coal bin. He was sure that the building was going to collapse, and just as he jumped the wind stripped the corrugated zinc off of the structure and he felt the building come right back; so I am quite sure if the corrugated zinc had remained in place the whole thing would have gone down. Two weeks after the storm an analysis was made of the different members and parts of the building and it was found that the bracing had been stressed to the very last degree; one more instant of the storm and the rivets would probably have failed.

Apparently one cannot design against a tornado when "the snout" of the thing hits the structure. Perhaps when you get a little outside of what the speaker referred to as the zone, one may build against the lighter load but that tornado snout went between the auxiliary and the main shafts, they are 500 feet apart, and everything between those two shafts was knocked out. The 500 foot conveyor bridge was cleaned, the machine shop was wrecked, the powder house was destroyed and they were right in the direct path of the tornado. The buildings to the east and west of the path were damaged, like the office, but not seriously. The tornado then went on by and cleaned out the C. & E. I. coaling station and shops, then on to No. 19 mine, left the tipple standing, wrecked the engine room, office and wash house, then to No. 18 mine where the top works were distroyed absolutely. You can take a straight edge lay it on the county map and it is almost a straight line between the two shafts at the New Orient Mine, the C. & E. I. coaling station, the No. 19 Mine wash house and No. 18 Mine.

None of the mine structures, at least none of the structures that I saw there, were destroyed, I will say, 100 feet either side of that straight line.

Now No. 2 Orient was not designed for tornadoes, and it would have been no discredit to the engineers if the plant blew down. I personally believe that if the cyclone really did hit the main tipple or the main re-screener along that straight edge line they would have gone down.

I am very much interested in the recommendations that were made as to how to build for cyclones, but you know we are always confronted with a lot of practical questions, and if we have to design a building against a tornado and it costs the owner ten or fifteen per cent more, he probably wouldn't permit it because a cyclone doesn't come around more than once in a lifetime. It is a question whether an engineer should design against those things. The matter of economics comes in there, the question of first expenditure of money for a given mine life. And even though one did so design, the peculiarities of a cyclone are such that the engineer wouldn't know how to proceed. You don't know which way the blamed thing is coming, you don't know whether it is going to have a twist in it or be a direct force.

The Dix River Dam

By L. F. Harza,* M. W. S. E.

Presented April 27, 1925

This paper is much abbreviated, to be followed later by a more complete technical paper, should our Program Committee so desire, for the reason that the dam is not as yet completed, and information is incomplete as to various phases which should enter into the final paper.—Editor.

THE Dix River Dam is 275 feet high, built of limestone on limestone foundation, and is of so-called "rock fill" type, a construction which has long been used in the West but not heretofore in the region east of the Rocky Mountains. This type of dam was devised originally by the placer miners of California who were compelled to use only the materials available at the site. The early dams consisted of loose rock fills differing in no respect from railroad embankments, except with a timber deck upon the upstream face joined at the bottom to timber sheeting or fitted to the rock bottom at the river bed, dependent upon the character of the foundation. Dams are frequently built today of the same construction in remote western locations for irrigation storage or for power. For the larger and higher dams a more permanent construction in the form of a concrete facing slab is usually provided.

A rock fill dam was first suggested for Dix River when a partial development of the head was proposed, as a type which would lend itself well to an increase in height without incurring heavy initial expense to provide for such uncertain ultimate increase. When initial development of the entire head was decided upon the study of this type was continued as well as of other cheaper types of dams then the conventional gravity concrete construction. The width of the canyon was a little too great to permit advantageous use of either the constant radius or constant angle arch. The hydraulic fill was not adaptable because of lack of suitable material if for no other reasons. The height was also far beyond precedent for the multiple arch type, and we did not feel safe in exceeding precedent to the required extent in this type by relying upon the assumed physical properties of a material so sensitive to conditions of manufacture as concrete.

The rock fill dam is a crude structure except in respect to its water-tight face. It offers little opportunity for architectural beautification. But the records of existing dams of this type, in our opinion, fully justify belief in its stability and permanency. It is also our opinion that this type of dam permitted increase in height of our structure beyond existing precedent more safely than by the use of other available types than gravity.

It is to be regretted that Dix Dam is so new that reference must be made largely to other structures for evidence presaging satisfactory behavior, and this is another reason why I wish to call this a progress paper.

The most important rock fill dams with chief data with reference to same are,

Swift Dam, near Valier, Montana, belonging to the Valier (Montana) Land & Water Company, built of limestone, 160 feet high above stream bed, resting on 30 feet of river bed gravel, total height 190 feet above bedrock, upstream face wall or slope paving 8 feet thick at bottom and 4 feet at top, faced with concrete 18 inches thick at bottom and 8 inches at top, sloped about 1 to 1.

Strawberry Dam, near Sonora, California, Sierra & San Francisco Power Company, built of granite, 160 feet high, provided for subsequent raising, face wall 16 feet thick at bottom and 8 feet at top, faced with concrete 18 inches thick at bottom and 9 inches at top, average slope 1.1 to 1.

Morena Dam, City of San Diego, built of granite, 150 feet above stream bed, with cut-off wall 112 feet below stream bed gravel and boulders, dry face wall 50 feet thick at bottom and 20 feet at top, to which was originally added six feet of rubble mortar masonry, and at a later

* Consulting Engineer, Chicago

date a concrete slab over a portion of the surface.

The question of stability as known to other types does not enter into the design of the rock fill. The design has not to any important extent been based upon theoretical considerations of overturning and resisting moments and internal stresses as in the case of gravity, multiple-arch or other dams, for the reason that a rock fill dam is not subject to failure from the same causes.

The three essential requirements of a rock fill dam are:

1. An ample spillway to insure against over-topping.
2. Conservative slopes, insuring stability against sloughing.

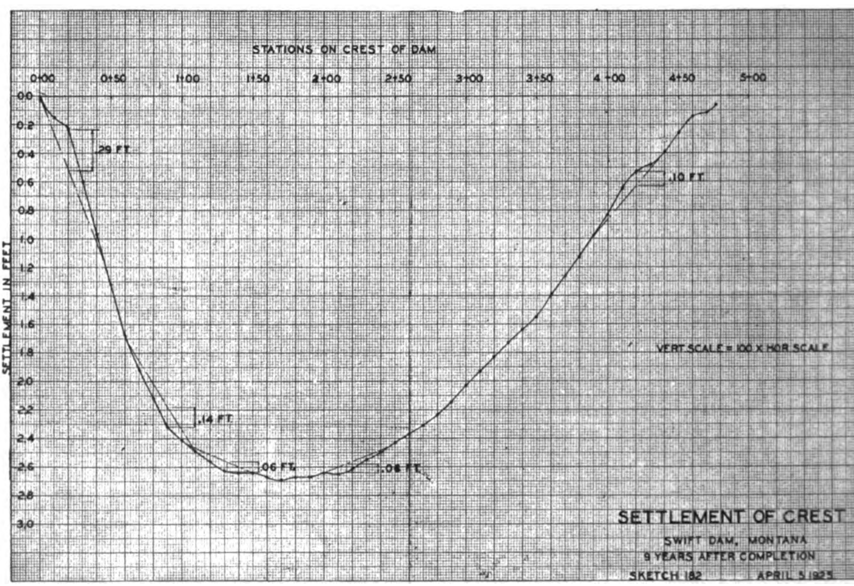


FIG. 1. SETTLEMENT IS PROPORTIONAL TO DEPTH OF FILL.

3. A flexible, water-tight diaphragm sealed into bedrock.

Spillway

A rock fill dam will be disintegrated on the lower side and destroyed, if overtopped by water in considerable volume, as in the case of the Lower Otay Dam.

The Dix River has a drainage area of 412 square miles, and a maximum known flood of about 28,000 second-feet recorded during thirteen years of daily observation, or about 70 second-feet per square mile. The spillway channel has a capacity of 200,000 second-feet, or about 500 second-feet per square mile, sufficient to discharge a run-off at a peak rate of 18.75 inches of depth per day from the entire drainage area. This spillway was cut through a depression in the adjoining hill, and the material was used for the dam.

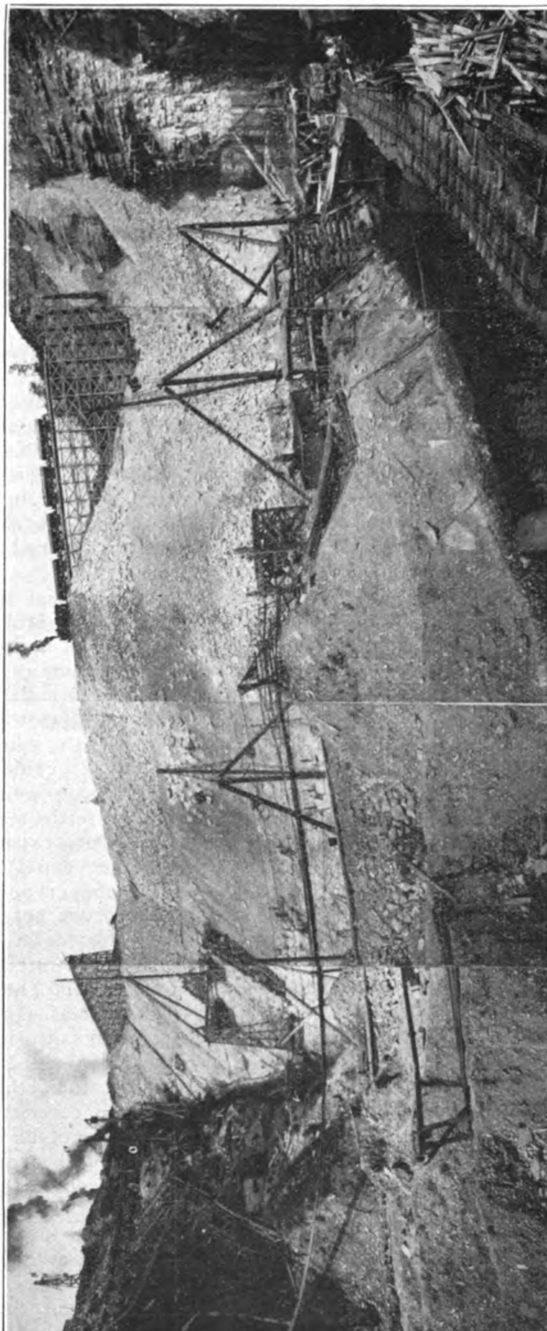
Slopes

The limestone composing Dix Dam comes to rest at a slope of about 1.3 horizontal to 1.0 vertical, when dumped with resulting momentum, over the top of a high slope. The downstream slope of the dam is 1.4 horizontal to 1.0 vertical.

The material will stand at a considerably steeper slope, if built upward rather than laterally, and especially when retained as on the upstream face, which is built on a slope of 1.2 to 1 at the bottom gradually changing to 1 to 1 at the top.

Face Wall

The upstream face of the dam is surfaced with a wall of dry rubble having a thickness normal to the face of about 14 feet at the base and about 7 feet at



COMPOSITE PHOTOGRAPH GIVING GENERAL VIEW OF CONSTRUCTION OPERATIONS.

the water level and four feet at the crest. This wall serves to smooth up and stabilize the surface of the fill for receipt of the concrete slab. It is built of large stones, three tons to eight tons, thoroughly chinked and wedged with spalls and breaking joints when possible throughout to prevent abrupt relative settlement of adjacent rocks.

Water Tight Element

Without an examination of existing structures, it might require some temerity to spread a sheet of concrete upon a settling fill, expecting it to remain intact without cracking. The first tentative design made by the writer consisted of slabs eight feet square, each capable of sustaining the entire pressure if supported at the edges or at the middle, and all slabs articulated at the joints with adjacent slabs to give great flexibility without loss of shear strength.

After thorough inspection of the principal existing dams. These refinements were concluded to be unnecessary. The writer had expected to find funnel-shaped depressions or sink holes, and various other irregularities of surface, but was unable to discover any such defects, or any evidence of cracking other than hair cracks. Settlement records where obtainable indicated the settlement to occur in each case in long, sweeping curves, the total settlement at any point being closely proportional to the depth of supporting fill at that point.

Fig. 1 is a diagram which shows the settlement curve of the crest of the Swift Dam, with vertical scale 100 times the horizontal scale, elevations being recorded every 10 feet. The largest deflections in 48-foot horizontal lengths are 0.29, 0.14, 0.10, 0.06 and 0.06 feet, and the total deflection is 2.7 feet in a length of 475 feet.

It would seem, from the evidence of existing dams, that the interlocking of individual stones in a high fill prevents abrupt settlement of one spot in a fill, with reference to the surrounding area. Moreover, with only ordinary care in distribution of material in the fill, the quality of material underlying a given area of the concrete face probably averages very much the same as the fill underlying any other similar area of the face, or in any event such changes in quality as do exist are not abrupt.

Assuming settlement to take place thus in long radius curves, the design of the facing slab becomes a matter of providing for proportionate depression of the general contour of the face of the dam and for the maximum probable settlement over a long period of time.

The concrete used in the facing slab of the Dix River Dam is designed and controlled to obtain a strength of 3,000 lb. per square inch in twenty-eight days. The slab has a thickness of 18 inches at the bottom, reducing to 8 inches at the top of the dam, and is provided with one-half of one percent of steel reinforcement in each direction, located in the middle of the slab to allow maximum flexibility. This is equivalent to 1% of reinforcement applied to the half thickness of slab which is effective as a beam. It must be remembered however that flexibility and not strength is the necessary consideration.

Our slab is so designed that a general deflection of the entire face of the dam, considered as a beam uniformly loaded, to the maximum amount of ten feet near the upstream heel where the depth of fill is small, and increasing to a deflection of 102 feet at the crest, where the depth of fill is about 275 feet, could safely occur without exceeding safe unit stresses in the slab, and local settlement in individual panels between expansion joints spaced 48 feet apart could occur to the extent of 1.73 inches near the bottom, increasing to 3.5 inches near the top, for normal working stresses in concrete and steel and about three times this amount before failure of either. These deflections for safe working stresses are all larger than the deflections measured for the Swift Dam, as shown in Fig. 1. It is therefore believed that the settlement which will occur in connection with the Dix River Dam will not be injurious and that the flexibility of the concrete facing will be ample to accommodate any prospective settlement without exceeding safe unit stresses either in steel or concrete, and without resultant cracking and leakage of the facing slab.

Most rock fill dams thus far constructed in the West were built for storage reservoirs for irrigation or municipal

water supply. Because of their use for storage purposes, they are drained at intervals of several years, if not every year, permitting of inspection. For a power dam, only a portion of the upper reservoir volume can be economically drawn out for power generation, and it is therefore imperative that the dam below the lowest limit of use of storage should be so designed and constructed as not to require subsequent inspection, entailing as it would the emptying of the reservoir and refilling of same after repair, with loss in operating period which in this case might extend from several months to a year, according to the wetness of the season.

Although we are confident that the slab of the Dix Dam is of sufficient flexibility to accomodate itself to any prospective settlement, yet in any rock fill dam the thickness of slab, and therefore water tightness, against seepage, must necessarily be sacrificed to some extent in the interest of flexibility. Inasmuch as the pouring of the facing slab on a slope of about 1.1 horizontal to 1 vertical necessitated the use of an upper form, it was concluded to make this form of high grade construction, using well seasoned 3x10 in. yellow pine lumber, tongued and grooved, to meet a special design, laying these forms with rough side downward well and permanently bolted into the concrete, and to leave these forms in place indefinitely from the river bed to Elevation 670, or for the lower 160 feet of height of dam, which constitutes the height that will be permanently submerged. It is the belief that this form lumber will swell to form a very tight diaphragm, as permanent or more so under water than the concrete itself, and that it will form the first line of defense against seepage through the facing slab of the dam.

Facing Slab Detail

The principal features of the facing slab, other than the thickness and percentage of steel reinforcement previously described, consist of the vertical and horizontal expansion joints. Vertical joints were spaced 48 feet apart, measured horizontally, and horizontal expansion joints were spaced 50 feet apart in vertical elevation, or about 70 feet along the slope of the dam. The horizontal spacing was chosen partly to accommodate stock lengths of facing lumber, but also partially in order that each unit of facing slab might constitute one day's continuous pour, the intention being to have no joints except at the expansion joints, unless through emergencies. Forms were designed which could be built up one plank at a time and were specified never to be more than four planks above the concrete, in order to permit thorough puddling and tamping.

The design of the facing slab of the Dix River Dam was far more elaborate and incorporated more precautions than any dam previously built. This was largely because of our own desire to meet all possible criticism in view of the fact that the dam is of a type unknown in the East and is higher than previous dams of its type.

One of our consulting engineers, M. M. O'Shaughnessy, is directly responsible for the introduction of horizontal expansion joints in the facing slab, which had not been used in any previous dams. Our other details were largely borrowed from other dams which have proven successful. Our vertical ribs between slabs were borrowed largely from the Strawberry dam, although we introduced the use of U-shaped copper seal strips to join the slab to the rib, and also the use of compressed cork for expansion joint material, as will appear later.

Tunnel

The diversion tunnel is about 913 feet long. Subsequent to its use for a diversion tunnel, it will be used for a pressure tunnel for supplying water to the turbines. It is concrete lined, of horseshoe section, 24x24 ft., without reinforcing, dependence for strength as a pressure tunnel being placed upon the depth of rock cover. The concrete for invert and side walls of the tunnel was poured in the usual manner, and that for the arch was blown in place by Ransome pneumatic placing equipment.

Closing Bulkhead

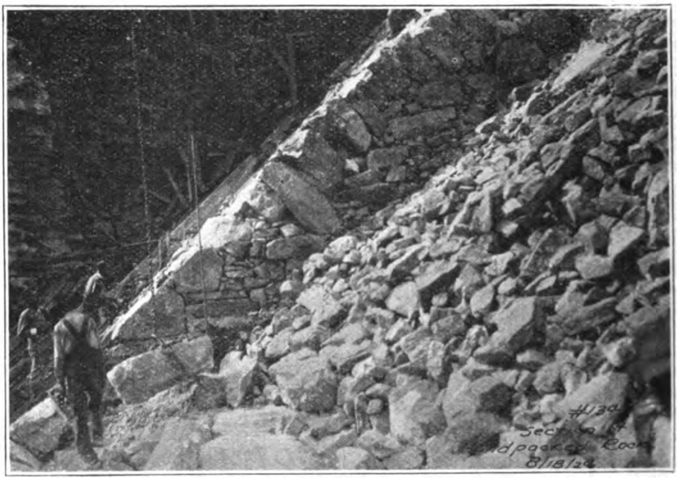
The 24x24 size of diversion tunnel was necessary only for passing floods. For closing purposes it was originally contemplated to pass the river through

the tunnel portal in a small pipe, perhaps 6 feet in diameter, at a low stage, and to build concrete around this pipe, same being provided with valves at each end, which would afterward be closed and the pipe filled with concrete by pressure grouting. It became evident in the summer of 1924 that closure could not be made in the fall before the advent of winter floods, and that closure would be necessary during the high water season. It was also evident that closure would need to be made before completion of the dam, and under conditions which would permit the dam to be continued upward ahead of the rise in the reservoir level; or in the emergency in which this could not be done that some means would need to be provided for exhausting water in a considerable volume; and in the ultimate contingency that the method provided for exhausting water did not prove to be of sufficient capacity to prevent the dam from being over-topped during construction, a method would need to be provided for again opening the diversion tunnel.

To this end a closing bulkhead in the form of a circular flap gate 26 feet in diameter at the seat was designed and constructed, hinged at the top above the upstream tunnel portal, arranged for lowering against a cast steel seat in the portal at time of closure. This bulkhead was designed to withstand the entire head of water, which will be 225 feet deep on the center line of the bulkhead and will produce a load of about 4,000 tons. It is built in the form of a cast steel rim, cast in six segments with flanged and faced ends, and with hinges in the top sections cast integral with the rim. To this cast steel rim there was riveted a plate steel hemisphere, concave upstream, thereby putting the plates and joints entirely in tension. This flap gate was lowered to closed position on March 17, at which time the storage of water in the reservoir commenced.

The hemispherical steel plate of this bulkhead is provided with a circumferential double butt-strap joint on a 20-foot diameter circle, having built into it between the butt-straps a ½-in. copper tubing, which is carried out and upward to the top of the adjoining hill. This was provided to insure against the possibility of over-topping the fill while completing the construction, if the plug gate to be described should prove insufficient in capacity. In this emergency the copper tubing could be filled with nitroglycerine and a 20-foot hole shot out of the steel plate, thus releasing the reservoir of water. The emergency which dictated this provision has now fortunately passed, and its utility will not need to be demonstrated.

The tunnel is to be filled in the near future with a block of concrete about



CROSS SECTION OF HANDPACKED ROCK FACING.

twenty feet long, behind this hemispherical bulkhead.

Plug Gate

Inasmuch as the diversion tunnel is to serve as a pressure tunnel for supply of the turbines, the horseshoe tunnel section was extended upstream of the face of the cliff, through a heavy block of concrete serving as the base for an intake tower. This intake tower was erected on this base structure just downstream from the concrete plug which will back up the hemispherical closing bulkhead. It is designed as a circular reinforced concrete chimney capable of taking the entire outside pressure when drained, and for the most part 22 feet in inside diameter, except near the bottom where it reduces in internal diameter to 17 feet and is provided with twelve ports arranged symmetrically around the entire circumference. Water entering through these ports is directed downward at an angle of about 45° below the horizontal, and radially inward toward the center of the tower. These ports are closed by means of a large concrete plug, 17 feet in diameter and about 30 feet high, provided with cast semi-steel sealing rings and seat rings and steel plate covering used as forms. It moves vertically in a clearance of 1/16 in. in the tower opening, seating when closed on a 45° seat at the bottom of the intake ports and also simultaneously sealing by means of a compressible seal at the top of these ports. This plug weighs 575 tons. It is hoisted through a steel plate pipe of 7/8-in. metal and of 4 feet internal diameter, extending downward through the plug and serving as a man-hole and air vent to the tunnel. This pipe extends upward to the top of the tower, to which attaches an oil-pressure hoist, in which a 15-hp. motor, driving a triplex high-pressure oil pump, provides a normal pressure of 3,700 lb. per sq. in. against the bottom of a 20 in. plunger for hoisting this gate at the rate of 2 in. per minute, the required upward movement being about 6 ft. 4 in. The housing for this hoist is reached from shore by a cable suspension bridge.

CONSTRUCTING THE REINFORCED CONCRETE FACING SLAB.

The large weight of this plug gate was dictated by the possible need for its use to exhaust flood-water through the intake ports, thence downward into the tunnel, after closing of the diversion tunnel through lowering of the hemispherical bulkhead previously described.

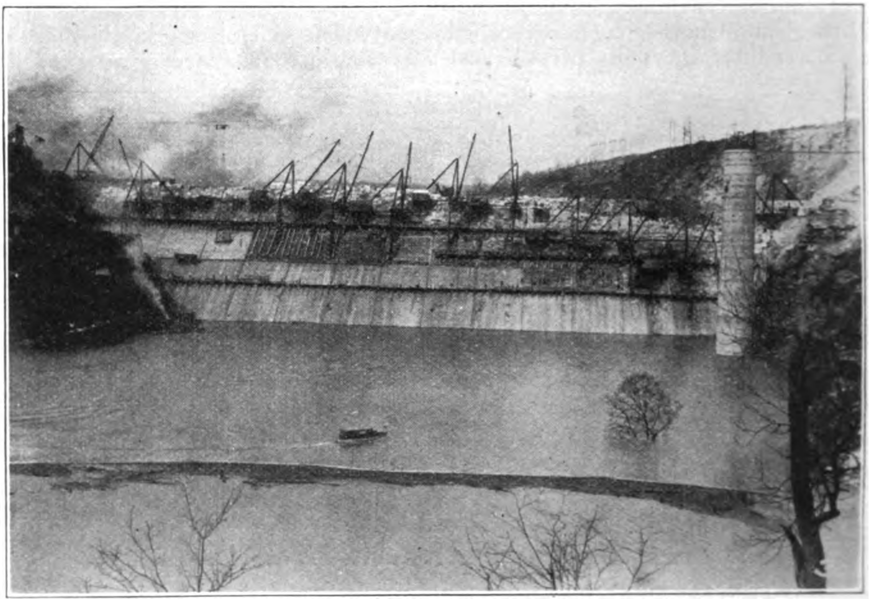
With free discharge of the gate under the computed maximum velocity of 80 feet per second, an upward reaction against the plug of 960,000 lb. would result as compared with the weight of 1,150,000 pounds. Under these conditions the gate would pass about 16,000 second-feet.

As soon as the dam has progressed to

such height that all possibility of needing to exhaust water through this plug has passed, the three 8-foot penstocks will be installed in the lower end of the tunnel. These will extend inward above the lower portal about 100 feet, and will be built into a concrete plug at their inner ends, about 35 feet long.

Bridges

In connection with this project it was necessary to restore the waterworks of the City of Danville, together with two highway bridges, which were flooded.



UPSTREAM FACE OF DAM NEARLY COMPLETED AND STORAGE OF WATER COMMENCED.

One of the highway bridges only is of special interest. The deck of this bridge was required to be some 250 feet above the original river level. After consideration of suspension and cantilever types, a new type of sub-structure was used which effected a considerable economy. Two hollow reinforced concrete chimneys were erected as bridge piers, same being contracted by the Weber Reinforced Concrete Chimney Company. One of these piers was 190 feet high and the other about 225 feet high. Three highway deck spans, each 210 feet long, were then erected by cantilever method across these piers, which will be submerged nearly to the top when the reservoir is completely filled.

Reference to the generating station, sub-station, transmission lines, etc., has been omitted inasmuch as the subject assigned to me is that of the Dix River Dam. In the more complete paper which I hope to prepare on this subject, I will expect to enlarge upon such matters as the details of the expansion joints in the facing slab of the dam, the settlement of the dam during construction and subsequently, the details of our grouting and results of same, and other details which could not be covered in the limited time available for the verbal presentation of this paper.

Arthur P. Davis, former Director U. S. Reclamation Bureau and M. M. O'Shaughnessy, City Engineer of San Francisco, both approved the design of the dam. George W. Howson is resident engineer on the work. The L. E. Myers Company, of Chicago, are the contractors, C. E. Collins, Vice President and General Manager, and A. L. Nelson, Superintendent on the work.

Engineering and the Public Service

By Maj. Alexander Forward*
Presented May 11, 1925

This is a sort of birdseye view of recent trends in public service that indicate some problems for engineers to solve. Others may see similar problems to be solved in other fields.—Editor.

DEFINITIONS, past and present, of engineering indicate pretty clearly the widening scope and the advancing ideals of the profession. Mr. Webster whose other name was Noah is of the opinion that engineering is "the art of constructing and using machinery; the art and science by which natural forces and materials are utilized in structures or machines." Messrs. Funk and Wagnalls take very much the same view, as follows:

"The science and art of making, building or using engines and machines, or of designing and constructing public works or the like requiring special knowledge of materials, machinery, and the laws of mechanics."

Dictionaries are likely to be a little bit behind the procession. Possibly one of the best definitions of engineering was by Henry Gordon Scott in his Presidential Address at the 1908 Convention of the American Institute of Electrical Engineers, that "Engineering is the art of organizing and directing men and of scientifically controlling the forces and materials of nature for the benefit of the human race."

"Engineering," says H. P. Gillett, "is the systematic application of science to the problems of economic production."

A. W. Kiddle is of the opinion that "an engineer is one who is engaged in practicing the art of science relating to the discovery, investigation and utilization of the principles, forces, properties and substances of nature and to the methods, means, devices, machines, apparatus and structures for employing the same."

I have a list of activities recognized as modern engineering specialties numbering fifty-five and ranging alphabetically from aeronautical to water supply.

In addition, we have efficiency engineers and the term has come to be applied to very many lines of human endeavor. In fact, the *Electrical World* said the other day that engineers will finally solve the problem of world peace.

A New Profession

The development of the public services, which occupy such a prominent place in the structure that we call civilization, has been extremely rapid. There are a number of persons now living who were alive when the first rail was laid on the first American railroad on the 4th of July, 1828, by Charles Carroll of Carrollton. Only a few years before the use of the steam was applied to transportation, gas began to be used for lighting the home in the centres of population. It is antedated in public service only by the water systems of the cities.

While the lives of a few persons span the entire period of modern transportation, the lives of most of us cover the era of the remaining agencies of modern civilization. Development of the telephone has come within a generation and now we can talk across the continent and even across large areas of water. Radio transmits the music of the opera and the speeches of the statesmen to hundreds of thousands of homes.

The application of electricity, which now furnishes the lighting for the greater part of our people and furnishes the power that drives the machinery of the nation, has been very recent. Since the dawn of the present century has come man's conquest of the air in heavy and controllable machines. Along with the remarks of the candidate for office, say, in New York, the reader in Chicago may see his picture the next morning in the act of delivering the address, through wire transmission.

In this development the engineer has played a predominant part. It is the merest truism to say that without engineering

* Secretary-Manager, American Gas Association, New York.

skill these developments could not have been brought without it; is equally true that without pre-vision of the future and recognition of responsibility in the solution of the problems of the age, these engineers could not have developed the modern wonders of the world. The engineer of today and the engineer of tomorrow must deal with the potentialities of the future and do their part in accomplishing the impossible as well as merely working out the immediate problems of the hour.

Must Be Economists

An engineer sits in the President's Cabinet as the head of the Department of Commerce. Engineers sit in the presidents' chairs of enormous business enterprises. They are in the councils of the great forces of the day. These are the engineers who are looking to the things that shall be.

An important phase of engineering in relation to the public service has come about in consequence of public regulation. The state and federal commissions have on their staffs men of recognized engineering experience and ability, and my own observation has convinced me that this field affords a splendid chance for education of an engineer and for promotion. Indeed, the commissions have difficulty in holding intelligent and resourceful men.

To those engineers who specialize in valuation work a large opportunity has been unfolded in recent years, more particularly since the close of the World War. Most of the utilities might possibly have run along fairly well upon a basis of return on money invested, provided always there were a uniform price level. Rapidly rising costs of all sorts of material and labor, as a result of the great conflict, made absolutely necessary a new basis upon which to calculate a fair and equitable return to those who had invested in the securities of public utilities. Not only had the cost of immediate material and labor gone up, and not only had the cost of all sorts of extensions and repairs risen accordingly, but the actual dollar of interest or dividend had lost from one-third to one-half of its purchasing power. Whatever may be the extent in which engineering is an exact science, certainly no degree of exactitude attaches to the work of a valuation engineer. This is because there are so many necessary variables in application of reproduction prices and of the price trend to the property, and more particularly because of the methods of appraising preliminary construction costs and the costs of developing business. Any two engineers could easily agree upon the physical enumeration of items of property, but show me two engineers who can agree upon a final determination of fair value. However, the labors of competent valuation engineers who can translate to lay terms is of inestimable help to regulatory bodies.

New Problems Arising

In that branch of the public service with which I am associated, there is a constant demand for trained men who know what has to be done today and who have a glimpse of what must be done tomorrow. The immediate future of the manufactured gas industry is one that demands the best thought of all concerned, including the executive, the accountant and the engineer. I do not here speak particularly of the problems which confront the manufacturers of gas-burning appliances, although they are many and varied. I want to discuss more particularly the outlook for the industry and what it means to the engineer.

The progress of the gas industry has been steady. When electricity supplanted the lighting load, the real era of gas use was begun, since the industry stirred itself to find newer markets. Sales in America have more than doubled in the last ten years. More gas has been made and sold since the World War began than in the entire preceding ninety years of gas use. Sales for industrial purposes have increased 1000 per cent, in twenty years and now constitute 24.5 per cent. of the total sales to the American people. Very soon the annual increase instead of 10 per cent. will be 20 per cent. and 30 per cent .and 40 per cent.

The New Fuel

It is as reasonable as anything can be that gaseous fuel must furnish the heat of the future. One of the most important reasons for this statement lies in the depletion of the supply of oil. The United States Geological Survey estimates that the total oil in the ground in our

country available for use is 9,000,000,000 barrels. Our present production is at the rate of 750,000,000 barrels annually. By simply dividing one figure into the other we get the result of 12, which would mean the total depletion of oil within twelve years. This is not to be taken literally since we know there are wells now operating that will be producing oil perhaps thirty or forty years hence. Besides, it is absolutely certain that within a very short time we will have conservation of this great natural resource, which we have wasted so prodigally.

The rapid growth of motor transportation has created an enormous demand for gasoline. An official of the United States Bureau of Mines gave me recently a statement showing that in 1909 the production of crude oil amounted to 588 barrels for each automobile. In 1922 this had been reduced to 114 barrels, in 1923 to 47 barrels, in 1924 to 40 barrels a car. This graphically indicates the rapid growth of the demand for automotive fuel. A committee of President Coolidge's Cabinet is considering this subject of conservation and it is a certain development of the very near future.

A Conservation Measure

The supply of oil must be carefully conserved so as to take care of the demands of transportation by road, by rail, by sea and by air.

We are told that oil now furnishes about 90 per cent. of industrial heating requirements which could be performed by gas. Undoubtedly as the available supply of oil for industrial processes diminishes manufactured gas will be called upon to take its place. The same thing is true to a considerable extent of natural gas, and in many localities even now artificial gas plants are being installed to replace or supplement the natural gas supply.

The end of anthracite coal is clearly in sight. While there is an apparently inexhaustible supply of bituminous coal in the ground, much of the best and easy coal has been taken and used. This fuel situation is no matter of guesswork. It is clearly recognized by economists, engineers and students in many quarters. The outlook is perhaps no better expressed than in a report prepared by the American Committee on Economy of Fuel and Economy of Raw Materials, which will be presented at the Convention of the International Chamber of Commerce in Brussels, Belgium, next month. The Committee has kindly permitted me to make use of this report and I quote from it the following significant facts:

"The United States has within its borders the largest supply of fuel in the world. Within a few decades nothing will be left except the various forms of coal. Imports, if possible, of liquid fuels may postpone their exhaustion for several decades, but it seems quite probable that by the year 1950 much the greater part of natural liquid and gaseous fuels will have practically disappeared. Present methods of using coal are wasteful; new methods of developing liquid and gaseous fuel from coal, by economical methods, are becoming more and more urgent. The vast resources of fuel in oil-shale reserves are untapped, awaiting the time when they can be mined and marketed economically."

"Large sections of the United States have for a long time been partly to wholly dependent on natural gas for fuel. The magnitude of the supply and its use are not generally known. In 1919 it was estimated that the consumption of natural gas in the United States was about one and one-half times that of artificial gas. It furnishes the most pitiful example of waste of fuel known. More gas has been wasted than has ever been used. The most ideal of all fuels, its use has been most careless."

"It must be remembered that fuel is, after all, simply the result of heat received by radiation of the sun during past ages. Any procedure, therefore, which will replace the fuel by utilizing the present radiant heat from the sun will be a great economy.

"Attempts have been made to utilize the heat of the sun directly by concentration of the sun's rays on some form of boiler and using the steam formed in a steam engine. Such attempts have been uniformly found to be impracticable."

The same report emphasizes some well known facts concerning the wastefulness and extravagance in our use of coal. It is dealt with as follows:

"In the average industrial power plant

not more than 5% of the heat energy in the fuel burned is recovered as useful power. The waste may be seen when we realize that the best large plants recover about four times as much. Considering the steam boiler alone, it has been shown that the ordinary plant shows no better boiler efficiency than about 57%. The best boiler installations are recovering 80% of the heat as steam. Explosive engines using gas as fuel show higher economies than the best steam engines, and prime movers of the Diesel type show efficiency twice as great as the best steam plant."

Smokeless Fuel

Again, our people are awakening in accelerated measure to the necessity of ridding our cities of the smoke nuisance. The economic loss is extremely heavy due to the necessity of cleaning the buildings, streets, stocks of goods, our clothing and our persons, of smoke and grime and soot. A comparison of the laundry bill of the average family between the smoky town and the smokeless town is very illuminating. Mankind will not tolerate smoke much longer.

Even if we did, the Health Departments will not for a great while stand for it. The modern physician tells us that smoke lessens vitality, reduces the capacity for work, opens the door in the human system to infections from respiratory diseases, and so shortens life.

The time is not far in the future when the burning of raw coal by any industry or any individual for any purposes will be prohibited by law and the consumption of this fuel limited to the gas and electric plants of the nation.

The same demands for the comforts and conveniences of life that brought about the abolition of the oil lamp and substituted the electric light therefor will bring about the abolition of the coal stove and the coal furnace. The householder will turn on the gas for the pilot light in the fall and turn it off in the spring and in the meantime his home will be automatically heated and thermostatically controlled.

On this same subject, the Committee on Economy of Fuel and Economy of Raw Materials, from which I have already quoted, has the following to say:

"Household heaters in private dwellings are usually greatly neglected. Poor construction of dwellings, uncovered pipes, lack of cleanliness in transmitting surfaces between the furnace and the air or water, incomplete combustion of coal, and the woeful lack of attention paid to proper humidity in the air of our dwellings, all contribute to this domestic waste.

"In some communities there have been developed systems of district heating from central stations, in some instances utilizing waste steam from electric or other power plants. But this system has its disadvantages, as such a fluctuating load is not a very desirable one from the standpoint of the power station."

Our electric friends have witnessed and will continue to witness a spectacular and romantic growth in uses for their product. Most of these developments have come within the past two decades. The electric industry, which commands the services of so many able and brilliant engineers, will have full play for its activities in the future in further development of power. Apparently it cannot compete with gas in the production of heat. As Floyd Parsons states so forcibly, "nothing will burn except gas." The gas industry burns the coal, extracts the gas and sells it to the consumer. The electric industry burns the coal, extracts the gas, turns it into power and then turns the power into heat. It does not seem possible that electricity can ever compete with gas in the supply of thermal units to the American people.

I quote once more from the report to the International Chamber of Commerce

"The lighting of our homes by electricity is becoming the usual, not the unusual thing; domestic application of power for use in household operations is becoming more common. But, except in very exceptional instances, we cannot expect that our homes will be heated electrically for it cannot be done economically. It is true that electrically-heated boilers have been designed and are on the market, but they will find application rather for casual use in the provision of

hot water supplies for temporary purposes, not at present at least for continuous heating."

An executive whose properties are both electric and gas, with a majority of electric, and whose name is known to all of you, says:

"On a competitive basis with gas for heating purposes, electricity is very much handicapped. With gas you can get four to five times as many B. T. U.'s from the original fuel at the same cost as you can with electricity, and under most economical operation. Where there is no gas service, of course, electricity can be used very advantageously, if the people are willing to pay the price. I think a good, wide-awake gas company can take a great deal of heating business away from an electric concern."

Fundamental Changes Taking Place

The same individual in figuring in another connection has calculated that assuming the same efficiency with all sorts of fuel, electricity would have to sell at 4.72 mills per kilowatt hour to compete with gas at a fair average price as sold in one large city, and gasoline would have to sell at 17½ cents per gallon and fuel oil about 19½ cents per gallon. I have indicated that the two latter products will show a rather rapid increase in price if indeed they are not made unavailable altogether for heating purposes.

I am not here predicting a revolution in the sense that manufactured gas plants now using oil must be quickly scrapped, but rather that the change will be gradual and will respond to profound economic laws. What I do mean to say is that the fundamental changes going on along the lines I have indicated will demand the very best thought and highest degree of skill in large volume of the engineering profession.

Undoubtedly within a short time as civilization counts years, we must plan for a gas industry three times its present size.

That grips the imagination. As the flapper says, one is "thrilled" by the opportunities afforded us today to play a potential part in the development of the service of mankind.

Professor L. T. Hobhouse, in his book, "The Elements of Social Justice," writes that one of the conditions of happiness "is that our life should be anchored in some object that takes us beyond ourselves, be that object another person, or our work, or the life of the community."

In his volume, "Work and Welfare," Mr. J. A. Hobson remarks that "A man who is not interested in his work and does not recognize in it either beauty or utility, is degraded by that work, whether he knows it or not."

It is put this way by Mr. William A. Robson in his book "The Relation of Wealth to Welfare," just off the press: "It is certainly true that a man's belief that he is contributing to a conscious effort to enrich the life of the community, or maintain the existing good in it, is, together with the status which is usually enjoyed by those who are recognized as helping to effect that purpose, one of the fundamental elements in the welfare of the individual. More than anything else does it lend him significance in society, and it is this which distinguishes the artist, the statesman, the scientist, and the other acknowledged "servants of mankind" from all who seek merely their own ends. All these workers feel that they are making an effort to achieve something beyond their own good; and, whether mistaken or not, they derive from that feeling an irreplaceable and essential element of the good life—."

That feeling is predominant today in the American Gas Association, and nowhere is it more unmistakably evident than among the industry's engineers.

TECHNICAL PAPERS

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The Hudson River Connecting Railroad

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There have been many illustrated articles published of different parts of the construction of the projects here described. This paper gives a general picture of the whole Castleton Cut-Off project. It is remarkable in that the author points out some of the difficulties that were encountered and the mistakes that were made, because of conditions that could hardly have been foreseen. The value to be obtained from such a paper is in the lessons to be learned from overcoming these difficulties.—Editor.

THE Hudson River Connecting Railroad comprises 26 miles of double track railroad and a divisional yard. It is the connecting link between the New York Central Lines to the west and north of Albany and the lines extending south and east to Weehawken, New York and New England.

All of the freight passing the Albany gateway will be taken into the yard and made up into trains for destinations both east and west. It will serve as the distribution center of east bound freight to be delivered east of the Hudson River, and a collecting center for west bound freight from the same region.

The westerly end of the road is at Unionville, on the West Shore Railroad. First is the yard which forms the east end of the Mohawk Division. The yard was graded for a capacity of 11,000 cars; tracks have been laid for 8,000 cars, and the design permits an enlargement to 20,000 cars. From the east end of this yard a branch extends south four miles to a connection with the West Shore Railroad at Ravena. The main line of the railroad extends eastward two miles to the Hudson River which it crosses on a bridge one mile long and 150 feet high, turns south on a descending grade and comes to the level of the New York Central tracks at Stuyvesant, nine miles below the bridge. Another branch extends from the east end of the bridge eastward to a connection with the Boston and Albany Railroad near Niverville.

Track grades through the yard are light. The main line is down grade all the way eastward; in the opposite direction the grade from Stuyvesant to the bridge is 0.35%. On account of the heavy passenger traffic on the Hudson Division of the New York Central, trains of 75 cars are as long as can be conveniently handled, and the regular road engines will handle such trains on that grade. The ruling grade on the branch to the West Shore Railroad is 0.25% both ways. Westward the branch to the Boston and Albany is down hill all the way; eastward the grade is 0.60%, which is less than the Boston and Albany farther east.

Entire System Will Benefit

The principal economic reason for building the Hudson River Connecting Railroad was that the old line was inadequate to handle the business and it was impractical to increase its capacity. The new road with its large capacity will enable the railroad to handle more business than it could formerly carry, and

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every part of the property will benefit from this increase.

There are many other advantages gained; some of the important ones are as follows:

The location of the improvement is such that the business of both the New York Central and West Shore Railroads is brought together in one yard, which will act as the distributing center for all business of the New York Central lines to the south and east of Albany. Also, the west-bound business will be brought together and made over into trains for points west. This will result in reduced cost of switching and, on an average, better train tonnage will be obtained.

The yards at West Albany, Ravena and Rensselaer have been required for making over the trains passing Albany. The new yard at Selkirk will now do all of this business, and as a result, supervision will be reduced, fewer switch engines required and the concentration of engine terminal facilities and car repair facilities will bring about additional economies.

Saves Time and Expense

On the former route there is a grade of 1.63% from Albany to West Albany, and a grade of 0.68% from Albany to Niverville. Pusher engines are used on these grades, which will not be required on the new route, resulting in a saving of 315 pusher engine hours per day.

It is estimated that there will be a saving of 6 hours time for each car passing through the Yard owing to better yard facilities, elimination of stops at the drawbridge and at two grade crossings. This will make a substantial saving in per diem expenses. The better line conditions will make a considerable saving in overtime.

There is a saving of 120 feet of rise and fall for all traffic to and from the Boston and Albany, and there is a saving of over 450 train miles per day on account of shortening the line. It has been calculated that the direct saving will pay the additional capital expenses, but the greatest benefit will be derived from the increased capacity and efficiency of the railroad as a whole.

Difficult Excavation Encountered

West of the Hudson River the location is on the bottom of a former lake. The surface of the ground is flat and intersected by ravines cut through the plain by stream action. The soil is brown clay to a depth of from 5 to 15 feet and below this is from 200 to 300 feet of blue clay.

East of the river the ground rises from the river flats on a steep slope to an elevation of 250 feet, beyond which is a rolling country. There are many deep ravines. There is much glacial deposit of hardpan overlaid with clays and sand. It is a very rough country especially between the bridge and Stuyvesant.

Most of the excavation was clay of one kind or another, and these clays have caused the most troublesome problems that were met. The brown and blue clays are not true clays but are pulverized slate and shale. They contain a large amount of water and have proved to be very unstable. The brown clay is easily dug and has not given much trouble in low fills, but when fills are more than 25 to 30 feet high, they begin to slump and will not support even the construction trains, until by settling and sliding the slopes have become as flat as 2 to 1 or 2½ to 1. It was necessary to lengthen a good many of our culverts which were originally built for a slope of 1¾ to 1. There were three fills of about 75 feet in height made largely of brown clay. After they were finally brought to grade they were allowed to settle for one winter, and when they were dried out the following summer, were covered with several feet of cinders and gravel. These fills have carried revenue traffic since last November without trouble, except one of the fills where the protecting material was thin, there have been several small slides. It is intended that the cinders and gravel will keep water and frost out of the clay, and with that accomplished it is not believed there will be any trouble.

Clay Unsuitable for Filling

It was never expected to use the blue clay in fills, but no trouble had been anticipated in disposing of the material in waste banks. It was soon found, however, that the material must be confined or it would run all over the country. A description of one cut will illustrate the character of the material and how it was

disposed of. This cut contained 177,000 cu. yd. of blue clay in a layer of 50 feet thick, and was excavated with a drag line. The machine would only reach one-half the width of the cut and one side of the first swath stood vertical for nearly its full depth of 50 feet for several weeks, but the effect of loading, hauling and dumping turned the clay into a semi-liquid. To confine the clay, a valley was selected with a flat floor of about 7 acres, upstream of the railroad embankment that crossed it. There was a culvert under the embankment and a vertical shaft was built at the upstream end. Four plank slides were built on the sides of the embankment and the cars of clay were dumped onto these slides. It slid down and flowed across the valley, eventually filling it to a depth of about 15 feet. Some of the clay flowed as much as 700 or 800 feet, and now the water runs over the top of the clay, down the shaft and through the culvert.

The first cuts in brown and blue clay were dug with slopes of 1½ to 1, and frequent slides occurred. The slopes were flattened to 2 to 1 and at this latter angle there has been little tendency to slide.

There has been, however, quite a tendency as the frost came out of the ground for the surface of the blue clay to slough off to a depth of a few inches and run down into the ditches. To stop this we will put cinders on the slope from the bottom up, probably about three feet thick, sufficient to keep the water and frost out of the slopes.

One feature of this sliding and sloughing of the material which had to be taken care of was the stoppage of the ditches. In some of the cuts the track is quite level and in order to take the water out of the ballast a 12-inch vitrified tile pipe is laid on each side of the track, below sub-grade, and every fifty feet there was a "T" put in and a quarter bend turned down. Stone was piled around that about up to the bottom of the ditch. They have been very successful in draining off the water, although the ditches may become clogged by the sliding clay. The ballast is drained and the water taken away, and a dry roadbed maintained.

Where the cuts have a blue clay bottom they were dug two feet below normal sub-grade and a sub-ballast of either gravel or cinders put in.

Methods for Excavation

There was a third kind of clay encountered, that was called indurated clay, but which would ordinarily be termed hard pan. It was a mixture of clay and gravel stones cemented that required blasting for its removal. The best success in blasting was had by drilling holes 25 feet deep and spaced 12 feet apart. Three-quarters of a pound of slow burning powder was used per cubic yard of excavation.

Most of the excavation was done with steam shovels, loading on 12-yard dump cars. In the yard where there were large areas of cutting less than 5 feet in depth and with haul not exceeding 1,000 feet, elevating graders were used very successfully. With twelve three-mule teams to a grader they moved about 800 yards a day.

In the blue clay cuts the material was not stable enough to support a steam shovel, and for these cuts large drag lines with 5-yard buckets were used. The draglines were kept on top of the cut generally loading the material on tracks laid alongside, but in two cases the ends of the cuts were so steep that a track could not be got on top. In these cases the draglines were located on top and loaded the material on a track laid in the finished cut, which was extended as the cut progressed; only two cars could be loaded at a time. The machines loaded 800 yards per shift under these conditions.

Small draglines, with ¾-yard buckets, mounted on caterpillar tractors and operated by gasoline engines were successfully used in trenching for water pipes and drains, trimming slopes and numerous small jobs.

Some Unusual Foundations

There was not much trouble with foundations. Where structures rested on brown clay the bearing area was designed for a loading of 2½ tons per square foot, and there was no settlement. The blue clay furnished a very insecure foundation. A description of two foundations in this material may be of interest. Coeymans Fill is 75 feet high and a culvert of 600 square feet opening was c-

quired. A box culvert was used with three openings, each 15 feet wide and 22 feet high. The site is underlaid with blue clay with occasional strata of sand 2 or 3 feet thick. Piling was driven over the area occupied by the culvert and a fair resistance was obtained owing to the strata of sand. Steel sheet piling, 24 feet long, was driven entirely around the foundation. A concrete mattress 70 feet wide, 230 feet long and 3 feet, 9 inches thick was placed on the piles. The side and top were then built on this mattress. There has been a settlement of about 2 inches at the center and nothing at the ends. The culvert was built in sections 35 feet long, to provide some flexibility to the structure.

Precautions at Turntables

There are two 100-foot turntables at the engine terminal. They are continuous girders with three-point support. The ground underlying the masonry is soft blue clay some 300 feet deep. Test piles were driven and when loaded to six tons per pile, began to settle, and the settlement though slow was continuous for two days. Piling was abandoned and a reinforced concrete mattress was adopted. The area of the turntable pit was excavated to a depth of 3 feet below the bottom of the masonry. Twenty foot steel sheet piling was driven around the foundation at the outer edge of the rim. The space inside was filled with cinders placed in 12-inch layers and rolled with a caterpillar tractor. The center and rim were designed for a loading of one ton per square foot. The center was an octagon 24 feet in diameter. The rim was 16 feet wide and reinforced so the load was distributed over a length of 20 feet. The space between the center and rim was filled with concrete 3 feet thick and reinforced against uplift in case the center and rim tended to settle and force the clay up between them. Reinforcement was also provided to prevent the center and rim under the table settling and the segments on each side raising. There was no precedent to determine what the upward force on the unloaded portions would be. The design provided against an upward force of 300 pounds per square foot in excess of the weight of concrete for the space between the center and rim, and an upward force of 100 pounds per square foot in excess of the weight of the concrete on the segments. The turntables have been in use for five months and there has been no settlement or cracking of the concrete.

Large Terminals and Yards Provided

The general arrangement of the yard is not an unusual one. There is an eastward section and a westward section each composed of a receiving yard, then a hump for gravity switching, next the classification yard and beyond is the advance yard. There are liberal thoroughfare tracks furnishing convenient means for engines to move about the yard.

There is a reclassification yard at the forward end of both eastward and westward classification yards. There is also an ice manufacturing plant, icing facilities and fast freight yard for eastbound traffic. The westbound fast freight is handled in the classification yard.

The hump switches are operated by electric power controlled from the tower located at the summit of the hump.

The Engine Terminal is located at the east end of the yard. There are two round houses; one of 30 and the other of 32 stalls. Up-to-date facilities are provided for preparing the engines for the next trip. There was considerable discussion on whether there should be one or two engine terminals. The Mohawk Division trains begin and end their runs 3½ miles west of the Engine Terminal. It was decided it was cheaper for the engines to run the extra distance than to build and operate a second terminal; but space has been left for one at the west end of the yard, if it is required in the future. A car repair plant is located in the central part of the yard to make running repairs. The water supply of the yard is from the Hudson River. We have a pumping plant in which the pumps are operated by Diesel Engines. There are two units, each having a capacity of 2,500,000 gallons a day. The Diesel Engine has been very satisfactory for the requirements.

Steep Grades on Humps

The humps have raised some interesting questions. The eastward hump was designed with a grade of 3% for 150 feet from the apex, an average grade of 1.45

from apex to beginning of ladders and a grade of 0.65% through the ladders. The corresponding grades on the westward hump were 3.5%, 2.07% and 1.00%.

Neither of the humps worked satisfactorily. Most of the empties and many of the loads stopped on the ladders and after 10 or 12 cars had been sent over, humping was stopped while the trimmer engine pushed the cars off the ladders and into the classification yard. The westward hump worked better than the eastward, mostly due to the steeper grade on the ladders. The eastward hump was raised 9 feet before reasonably good operation was obtained in winter weather. It now has a grade of 5.5% for 150 feet from the apex, an average grade of 2.25% from apex to the beginning of ladders. The 0.65% grade through the ladders was not disturbed. Observations during cold winter days showed a car resistance as high as 40 lb. per ton, and nearly all the empties and an occasional loaded car had a resistance of between 30 and 40 lb. per ton on very cold days. A hump profile is suggested as follows, beginning at apex:—200 ft. 4%, 600 ft. 2% to ladders, and 1.5% through the ladders. This may be somewhat steep for summer work but nothing less will work satisfactorily in zero weather.

Flood lights are used for general yard lighting. Projectors mounted on 75-ft. poles throw the rays of 1,000-watt lamps horizontally over the yard. From 4 to 9 projectors are placed on a pole. A moderate light is diffused over the yard with very little shadow. It is very satisfactory.

High Bridge Over the Hudson River

The bridge over the Hudson River is an important part of the project. It is one mile long, the track is 150 feet above high water and the under-clearance is 135 feet. There are two spans crossing the main channel; one is 600 feet, the length required for that portion of the channel maintained for navigation, and the other 400 feet for the remainder of the channel. There is a viaduct approach on each side of the channel. The viaduct is of standard construction, the tower spans are 64 feet and the connecting spans 100 feet. The viaduct pedestals on the hillsides at each end rest on rock or hard pan. Across the bottom land, the pedestals rest on piling driven to rock. There are 81 piles under each pedestal. The viaduct was erected by a traveler with a 110-foot boom. It rested on the girders and set the steel ahead. The floor of the traveler was supported on legs of a height to allow the material cars to run under it; the traveler picking up the pieces in front. The viaduct has a reinforced concrete deck and ballasted track. There is a sidewalk and railing on each side.

The truss spans are of the K type with riveted joints throughout. The spans rest on masonry piers sunk to rock. From 9 feet below high water to 17 feet above, the piers are faced with granite, the remainder of the masonry is concrete. The piers are designed so there will be no tension at any point; but some reinforcement was used as an additional security. The west and center piers were sunk to a depth of 47 and 52 feet respectively, by means of pneumatic caissons of reinforced concrete.

Piers Built on Concrete Caissons

The method of constructing the piers was as follows: — First, an island was made at the site of the piers and the caissons were cast in position for sinking. After the concrete had set, the excavation began, first using buckets until a depth of 10 feet below water level was reached. From that point most of the excavation was blown out through pipes running up through the masonry. Until a depth of 10 feet had been reached, sufficient air pressure within the working chambers could not be maintained to blow out the sand, but at that depth the air in the working chambers would blow the sand out. The bottom of the pipe was sunk a little below the cutting edge and the sand was just pushed to the bottom of this pipe and the air escaping blew the sand along with it. As the caissons sank, concrete was added to the top until it was built up to the point where the stonework began. Above that point a coffer dam was built to above high water, and after the caissons were landed, the working chambers were filled with concrete and the neat work started within the coffer dam. The rock at the east pier was 30 feet below water level, and the foundation was built in an open

cofferdam. The river bed was silt and fine sand to within 6 inches of the rock. There was a 6-inch layer of hard pan overlying the rock. Steel sheet piling was driven through the hard pan to the rock, which was nearly level. The material within the cofferdam was excavated with a clam shell bucket. The bracing was installed as the excavation proceeded. To start with sets of timber were built with posts to separate them, and as the digging proceeded, they were driven down. It was hoped that this could be carried way to the bottom, but after they got about half way down the sheeting was enough out of line so the bracing bound on the sheeting and after that the sets had to be put in as the excavation proceeded from below. There was very little leakage into the pit, and a three-inch pump run continuously would have kept it dry. The action of the bracing indicated that the greatest pressure against the sheeting was about half way down, and below that point it decreased. This was accounted for by the character of the material forming the river bottom. It was loose near the top and the upper part of the sheeting received the hydraulic pressure. Further down the water ran into the cofferdam faster than it leaked through the river bed, and as a result there was not much more pressure near the bottom than that produced by the pressure of the sand itself.

I don't want anyone to infer that they can rely on the pressure on a cofferdam acting that way. It is very rarely that you have such a peculiar soil that the pressure is less at the bottom than it is half way up.

Steel Bents Used for Erecting Spans

The truss spans were erected by the cantilever method, the 400-foot truss being erected first. There are 14 panels in the truss. First, three timber bents were erected at the three easterly panel points and three bays of steel were erected on them. At the panel point 4-E a steel bent was placed on a substantial pile foundation and the erection continued by means of a creeper traveler on the top chord to panel point 4-E and the load of the 4 panels shifted to the steel bent. Erection continued cantilevering to panel point 6-E, where a second steel bent was placed and the load shifted from panel point 4-E to 6-E. Erection continued to 6-W and the steel bent at 4-E was taken down and re-erected at 6-W. The two bents were now symmetrical with the center of the span and supported it until erection was complete and the west end rested on its pier.

Truss Held in Line with Jacks

To keep the truss at the correct elevation and maintain the right profile of the lower chord over the bents at panel points 6-E and 6-W, four 500-ton hydraulic jacks were placed under each chord at each bent. As the erection proceeded, the additional weight deflected the truss more and more, so the elevations of the supporting points were constantly changing and were readjusted with the jacks. As it approached a quarter of an inch out of the calculated elevation, it was adjusted by the jacks. They did it very easily and quickly. If the relative elevation of panel points 6-E and 6-W varied more than one inch from the calculated profile, the chords would have been overstressed. The lower ends of the center diagonals between 6-E and 6-W were left disconnected so that there could be no shear except what the stiffness of the chords would take between these panel points. This was to prevent one of the bents from being overloaded in case there was unequal settlement. It was frequently necessary to jack the panel points up or down.

Timber bents were not necessary to start the erection of the 600-foot truss. A tie was placed between the hip joints of the 400 and 600-foot spans, and blocking was placed between the bottom chords. Thus supported, the 600-foot span was cantilevered to panel point 4-E, where a steel bent was placed. Erection then continued to panel point 6-E, when the only real difficulty of erection of this bridge was encountered. It was a movement in the foundation of the bent at panel point 4-E.

Temporary Foundations Permit Movement

The foundations of the bents under the 400 foot span were in water 10 feet deep and the piles all went to rock, making very strong foundations. Under the 600 foot span the water was 20 feet deep and

the rock was too deep to be reached by piling. Bent 4-E was supported on two pile clusters, each composed of 72 piles. Each cluster was surrounded by steel sheeting driven 14 feet into the river bed, and the interior was filled with sand to act as bracing. The space enclosed by the sheet piling was 22 feet in the direction of the axis of the bridge and 32 feet at right angles. The loading on the piles including the wind load was calculated as 33 tons per pile, but this did not take into account the sand filling placed around the piling. This filling added something, perhaps as much as 7 tons per pile, and while it prevented the piles from buckling, it was not of much value as bracing because it would not take shear.

When the erection reached panel point 6-E there was a high wind. The next day it was found that the top of the foundations had moved north 4½ inches. The north foundation had moved east 4 inches, and the south foundation had moved west 8 inches. The piles had settled from 1 to 1¾ inches. The truss itself was out of line 3½ inches.

There was one substantial force tending to hold the bridge in line. Each end bearing was anchored to the masonry with eight 1¾-in. bolts and fourteen 1½-in. bolts, all extending 15 feet into the masonry. These were installed to take a small uplift that would occur just before the bridge was swung. The anchors stretched some but they held. The difficulty was corrected by driving a cluster of piles on the north side of the bent, some vertical and some brace piles, to jack against, and driving a pile cluster to the south of the bent for attaching blocks and falls. By jacking and pulling at the same time, the bent was gradually forced back to place. It could only be moved ½ to ¾ of an inch at a t'me, but after resting a while, it could be moved again. After it was religned, brace pulling was driven around each foundation, and there was no further trouble. Brace piles were also driven around each of the foundations for the second and third bents, and no trouble was experienced with them.

Large Rivets Require Special Care

Some interesting problems arose in connection with driving the large rivets used in the chord splices. One-inch rivets were used for all chord splices of the 400-foot span and at the ends of the 600-foot span and 1⅛-in. rivets through the central portion. The grip varied from 4 to 6½ inches. Tapered rivets were used. The driving was done with No. 90 Buyer guns, and the bucking up was done with pneumatic hitting jacks.

Rivets that tested hammer tight at both ends were cut out and it was found that they did not fill the hole generally through the middle portion and frequently at the ends. In many cases the rivet was 1-20 of an inch less in diameter than the holes. Considerable experimenting was done before satisfactory rivets were obtained. A rivet was considered satisfactory if it came within 1-64 of an inch of filling the hole throughout its full length. Both the rivet and the rivet hole were measured with micrometer calipers. After considerable experimenting by taking the following precautions, tight rivets that completely filled the holes were obtained:

1. Rivets with a larger taper were furnished to more nearly fill the holes before driving commenced. The tendency was for the holes to be oversize and the rivets undersize. There cannot be much upsetting during the short time before the head is formed sufficient to prevent further metal flowing into the hole. It is therefore necessary that the rivets be as large as will enter the hole.
2. The sharp edges of the holes were reamed off so the metal would flow more easily into the hole as the rivets upset.
3. The paint in the holes was burned out and they were thoroughly cleaned of cinders and dirt.
4. Forges were obtained of a size sufficient to heat the rivets uniformly for their full length. When the rivets were taken from the forge, the field end was quenched to cool it slightly so when driving started the body of the rivet upset sufficient to fill the hole before the head formed.
5. Rivets were scraped clean of scale before inserting in the hole.
6. Plungers were lengthened from 3½ to 4 inches; the heavier plunger being more efficient to upset the rivet.
7. The hitting jack was run intermit-

tently throughout the driving. This method gave better results than were obtained by stopping the jack when the rivet was home, or running it continuously all the time the head was being formed.

After all these precautions had been determined on and the men got used to them, good rivets were obtained. One per cent of the rivets were cut out and tested, if they measured all right, we considered the joint was good. If there were any bad rivets found, more were cut out, and if there were a good many bad rivets found, the entire joint was cut out. After a few experiences of that kind there was not much trouble.

In this paper I have dwelt quite a good deal on the difficulties we encountered on this line, not to exaggerate them, but we learn more from difficulties overcome than by any other way.

DISCUSSION

Mr. Jordan: In so large a rivet it is very difficult to make a rivet upset, there is such a reluctance of steel to flow. If the head of the rivet had been struck with a large hammer, say a ten-pound hammer, it would have upset, but with that rapid tapping of this little light hammer it just batters the end down quickly and there is considerable reluctance of steel to flow into the hole. The most vital part of it was to heat the rivet for its full length. In nearly all riveting they heat the field end of the rivet and oftentimes the shop end is almost black. A large forge is essential, and I think the quenching helped.

Robert H. Ford, M. W. S. E.: Mr. Jordan has described an important piece of modern railway terminal construction in a very interesting and decidedly unusual manner. He has described some things but if they had had the experience at the start, would not have been done the way they were and he has very frankly explained some of the things in which they were unsuccessful and what measures were taken to correct them. He can content himself with the fact that in reality most all large jobs involving varied conditions have similar situations but it is seldom that a reporter favors his readers with this character of information. The subject has been treated in a broad, constructive manner.

He stated that a line was built by the New York Central through to New York on a .25% grade and it is not clear why the limitation was placed for 75-car train. Presumably this was for some local operating reason and does not refer to the ability of the plan to permit the 25% or 30% increase over this with corresponding return on the investment.

He also referred to a .6% grade on the Boston & Albany, indicating that it was consistent with the grades on that line. Presumably, he referred to this engine district. Grade revision through the Berkshires and the territory traversed by the Boston & Albany is not a very simple matter. Nevertheless, the traffic of the country will sooner or later require that with dense traffic like the Albany, they shall go to at least .5% and probably below. I appreciate that a grade of this character through the Boston & Albany territory is more of a problem than the average man realizes.

The type of foundation of the turntable is interesting. There was probably some good reason why this was not built in two sections or with a separate foundation.

It would be interesting to know how near to the center line the foundation of the river pier came when finally rested.

Mr. Jordan: In regard to the grade on the Hudson Division connection, or the connection down to Stuyvesant, the Hudson Division of the New York Central Railroad is a line of very heavy passenger traffic. The freight and passenger trains operate on the same track and 75 cars is as many cars as they have cared to handle on that division. The freight traffic is secondary to the passenger traffic. They want a train they can get out of the way quickly. That was the Operating Department's decision on the matter. Now, the engine that is used to pull the 75-car train over the Hudson Division connection will handle a train up the .35% grade. If they care to increase the length of the trains—and even now they are increasing them to 85-car trains,—they will have to have a heavier engine, and that heavier engine will still handle it on that .35% grade.

As regards the Boston & Albany grade, I doubt if the grade can be cut down to .5%. On this line we have one cut of 87 feet and the nature of the soil there is such that deep cuts are very objectionable. What will probably be done with the Boston & Albany will be to electrify it. That is being considered now and that seems to be probably the economical way of operating that railroad between Selkirk and Springfield.

The question you asked about the turntable, of course when we discovered the condition of that soil, the turntable had already been ordered, but what we consider the best turntable is the continuous girder. It is very much superior to the balanced turntable.

There is a turntable now on the market which has a vertical flexibility at the center. Of course, it has to be made stiff laterally. The table is made of two girders attached to each other with angle irons, and the outstanding leg of the angles springs to give it a certain amount of flexibility. The tables which we have built are shallow continuous girders and will spring a couple of inches, before very much additional stress is put into them due to the deflection.

The three-point-support table is far superior to the old balanced table. It stops all of that hammering on the ends. There is a certain allowance for adjustment in them in case of settlement of the foundations. Fortunately, we haven't had to use that yet.

The humps were originally designed from several humps the railroad company had and which were reported to work satisfactorily. As nearly as I can make out what happened, our Designing Department got hold of the original profiles and when they were built they didn't work very well, so the local men raised the apex and made no report of it. As a result, the designing department didn't get the right grades. I think I recommended a grade here which I will repeat. My suggestion was for starting at the apex with 200 feet of 4-per cent grade, then 600 feet of 2-per cent to the ladders and 1½ per cent through the ladders. That is a hump that will handle cars in the coldest winter weather. My theory of it is that the 200 feet of 4-per cent grade will give the car such a start that it will run away from the following car. To give the proper spacing between cars; that the 600 feet of 2 per cent, with 20 pounds car resistance will maintain the speed acquired on the 4% grade. Then, with 1½ per cent through the ladders, the car will very nearly maintain its own, perhaps by the time it has gotten down to the ladders it will have limbered up a little, and I think with that grade all cars will run in clear of the ladders except possibly in a few of the very severest days of winter.

There is a great difference in a train which has only laid in the yard an hour or an hour and a half and one that has laid there for perhaps ten or twelve. The worst train I saw last winter laid in the yard for twenty-four hours and the cars simply wouldn't run at all, they were frozen stiff. I believe in a heavy grade through the ladders, and have suggested one and one-half per cent, which I think is about the grade that a car rider can conveniently control the car in summer weather when the cars run very freely. I was very much surprised at the car resistance. I couldn't believe that it ever got as high as forty pounds, but I found that it did.

E. D. Swift, M. W. S. E.: We have on the Belt Railway of Chicago a very large hump yard cut here at Clearing. I wouldn't want to say, offhand, just what all the grades are, but we start off at the top with four per cent on both sides. That is, our hump-over yards are symmetrical each way from the hump, operating both East and West, and the situation is a little different from the one that you described in your new yard, where you have different gradients at one side than on the other. With us it just happens that the heavy loads go against the wind, so the hump each way has the same grades, that is, the coasting effect. We start off from the top of the hill with a four per cent grade, 0.9 per cent on the ladder tracks. We don't get very much weather as cold as that which you talked about. In real cold weather the cars sometimes practically refuse to run at all. There have been cases where we have had to take them out on the approach track and run them up and down a couple of times in order to warm up the boxes sufficiently.

Structural Design of Bridges in Grant Park

By C. R. Hoyt*

Presented September 14, 1925

This paper sets forth some of the problems that had to be solved in connection with the designs of the viaducts over the Illinois Central Railroad tracks in Grant Park. That space is so valuable that every inch of it had to be utilized to the best advantage which condition dictated the use of slender columns and long spans. The City ordinances prohibit any structure extending above the retaining walls which eliminated the overhead type of construction. The studies made to design bridges come within these limitations are here described.—Editor.

IN 1912 the South Park Commissioners made an agreement with the Illinois Central Railroad Company, and the City of Chicago, to build certain bridges across the Illinois Central right-of-way between Randolph Street and Roosevelt Road. These bridges were to replace the bridges located at Van Buren Street, Harrison Street and Eighth Street, two of which have been wrecked and the third at Eighth Street strengthened for temporary service.

In the general layout of Grant Park, from Randolph Street to Roosevelt Road or Twelfth Street highway bridges are to be located at Jackson Street, Congress Street, and Seventh Street; and foot bridges with step approaches on the west at Van Buren Street, Harrison Street, Eighth Street and Ninth Street.

Congress Street, with its big double bridge, forms the axis about which the architectural design is centered. The approaches to Congress Street rise in long sweeping curves which form a plaza with steps leading up on the center line of the bridge. Flanking this bridge are two large pylons 300 ft. on center, towering 65 ft. above the roadway, with a main shaft approximately 24 ft. square. On both sides of the Congress Street bridge, just east of the Illinois Central Railroad, are large colonnades. This ensemble is designed and intended to form an appropriate setting for the Buckingham Fountain which, in turn, is the crowning feature of the aesthetic treatment worked out for the Park.

North and south of the Buckingham Fountain are athletic fields designed to have ornamental concrete retaining walls. To the South is the Field Museum, east of which will be located the new Shedd aquarium, and west of which will be located the new Illinois Central Terminal, both buildings to be designed to conform to the architecture of the Field Museum. Throughout this whole design are smaller fountains, ornamental steps and picturesque landscaping.

One of the biggest problems in the design of the various bridges was to make structures that would harmonize with the surrounding architecture. Figure 1 shows a plan and elevation of the bridges to be located at Jackson Street, and Seventh Street. The lengths of spans, 40 ft. 8 in. for the west span; 93 ft. 0 in. for the center span; and 66 ft. 4 in. for the east span were adopted only after considerable study by the Illinois Central Railroad Company, as to the possible location of columns to meet with the track layout plans.

On the left are shown the small pylons which are located on each side of these two bridges, at the west end only. The balustrade is of an open design with turned balusters, all made of precast concrete, substantially tied into the bridge proper. The entire structure is encased in concrete, as the aesthetic treatment of Grant Park made it advisable to use a concrete structure, and this concrete covering had the added advantage of low maintenance cost.

The east curb of Michigan Boulevard at Jackson Street is at elevation plus 15.75 and at Seventh Street is plus 14.75 and continuous at this latter elevation south to Eleventh Place. The top of rail of the Illinois Central tracks is about elevation plus 6.0. The distance from the east curb of Michigan Boulevard to

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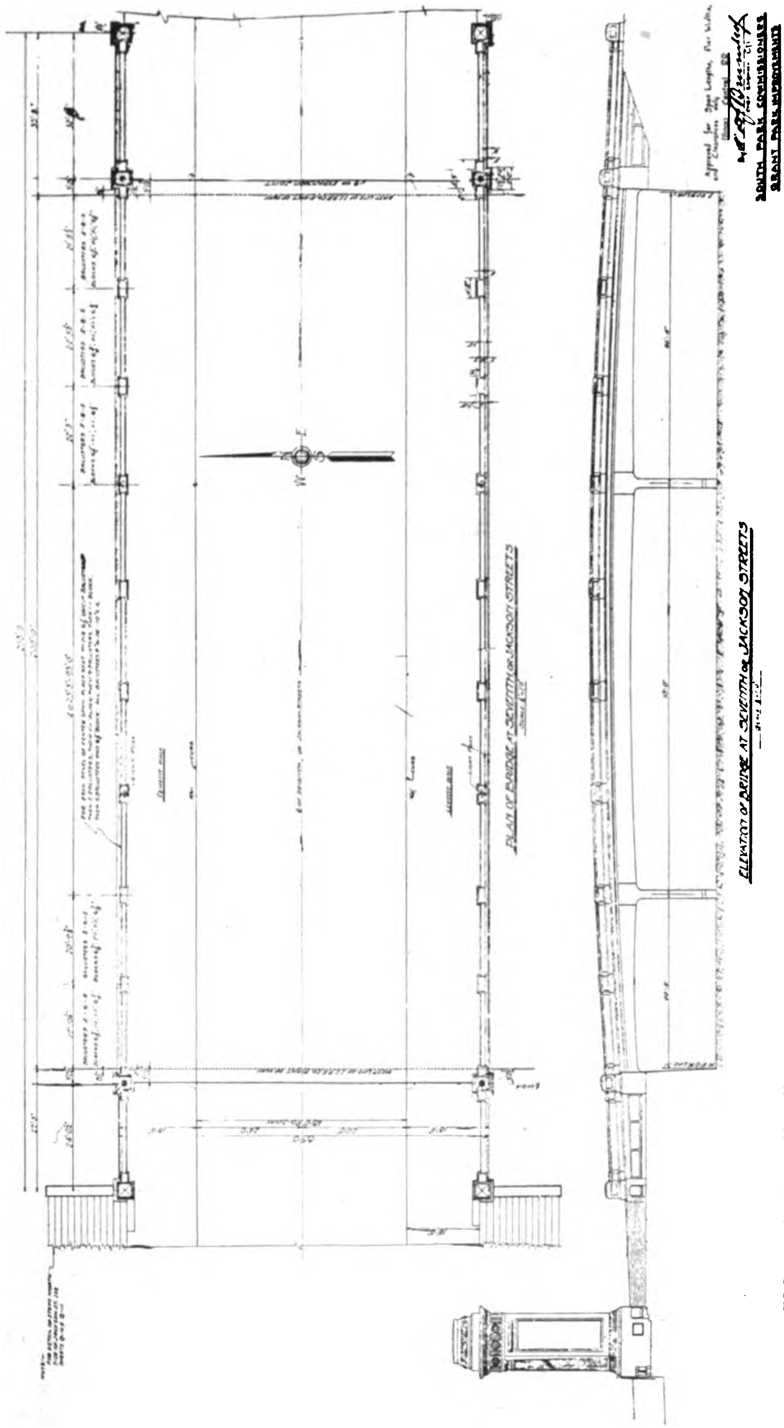
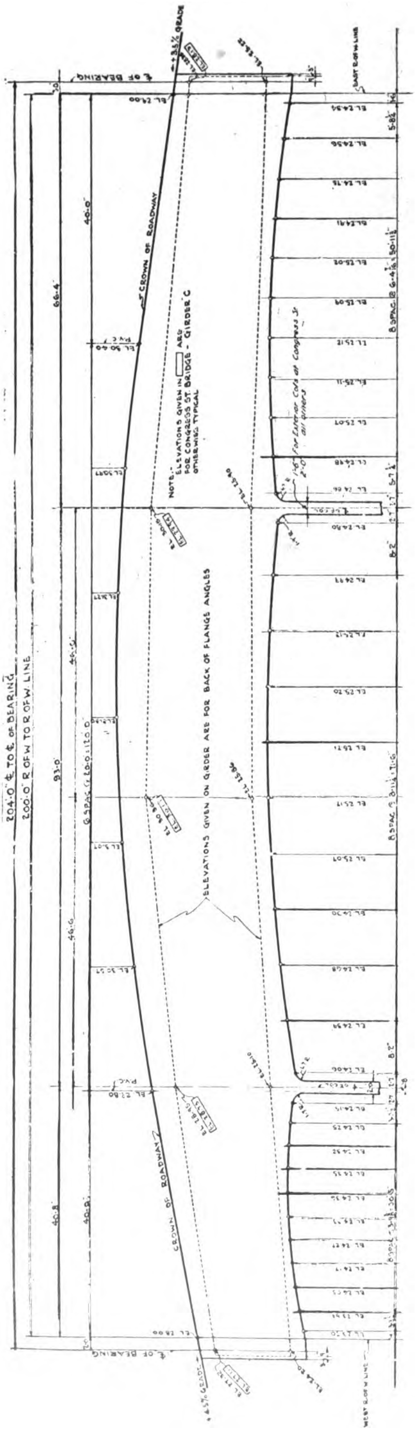
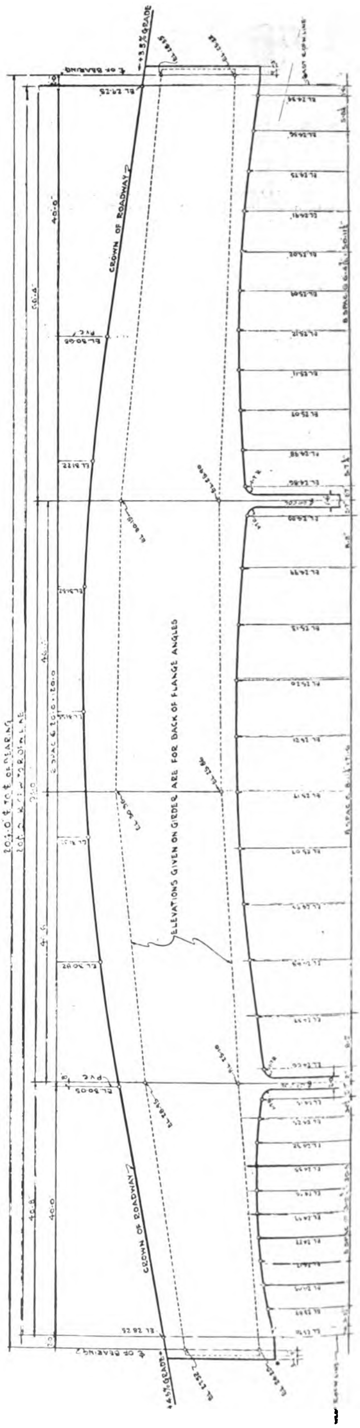


FIG. 1. PLAN AND ELEVATION OF BRIDGES TO BE BUILT AT JACKSON BLVD., AND AT SEVENTH STREET.



CLEARANCE DIAGRAM FOR BRIDGES OVER I.C.R.R. AT JACKSON ST. CONGRESS ST. & 7TH ST.



CLEARANCE DIAGRAM FOR BRIDGE OVER I.C.R.R. AT HARRISON STREET

FIG. . STUDIES OF CLEARANCES WHICH DETERMINE THE TYPE TO BE USED

the west right-of-way line is 295 feet. The overhead clearance above the top of rail, as fixed by the aforementioned agreement, is 18 feet so it is at once seen that the approach grade from Michigan Boulevard was a matter that required careful study.

To keep these grades to a minimum, shallow girders were necessary. The Illinois Central tracks are on a reduced lateral clearance of about 12 ft., 10 in. centers and this clearance eliminates any possibility of constructing falsework for supporting concrete. These three factors, viz., shallow depth of girder; long spans, and inability to use falsework, contributed to eliminate reinforced concrete girders from consideration and pointed to the desirability of steel construction encased in concrete and gunite.

After the column locations and the kind of construction were decided upon, the next step was to decide upon what type of girder would be the most advantageous for the condition under which the bridges had to be built. For comparative study, three types were selected, viz., a deep continuous girder; a shallow continuous girder and a cantilever design.

The cantilever design consisted of a cantilever span fixed at the abutment and cantilevering over the column from each end. A suspended span was then to be swung between the extended cantilevers with a pin connection at one end and a rocker connection at the other, to take care of expansion and contraction. This proved to be the most economical type of bridge, but presented the following difficulties: first the construction was not as rigid as for the continuous type; second the approach grades were greater than necessary for the shallow continuous girder, and the third this bridge had to be encased in concrete. This meant unsightly expansion joints that could not be avoided. It involved details extremely costly for encasing the girders at the joints and still leaving the joints free to function.

The deep continuous type had only one of the disadvantages of the cantilever design, i. e. increased approach grades which were considered undesirable. This girder was designed as a three-span continuous girder with expansion bearings on both abutments, and was about one foot deeper than the shallow continuous type which was finally adopted. As the shallow type embodied all the advantages of the continuous construction where long spans and shallow depths had to be met and, at the same time gave a more reasonable approach grade, the advantage gained in the matter of approaches seemed to warrant the small increase in cost of the shallow type over the deep type.

A unit price was applied to the various quantities involved in the separate designs and the following comparative square foot prices determined.

The Cantilever type cost $9.05 per sq. ft.

The deep continuous type cost $10.40 per sq. ft.

The shallow continuous type cost $10.75 per sq. ft.

Before the final design could be made it was necessary to construct the clearance diagrams as shown in Figure 2. The elevation at each right-of-way line was laid out and the necessary approach grades through these points were connected with a 120-ft. vertical curve. This located the position of the crown of roadway, throughout the length of the bridge. Next the lower curves connecting with the columns were laid out. Between these two curves the outline of the girder was placed, allowing for the finished roadway surfacing, encasing, and necessary cover plates. The assumption made as to clearance necessary from back of angles was corrected after the preliminary design and finally tested after the finished design was completed. It was essential to obtain the greatest possible depth of girder between the selected clearance lines in order to reduce deflections to a minimum. All girders were made the same depth, back to back of angles for ease in fabrication and to eliminate the necessity for varying the fiber stress in the various girders to insure equal deflections.

The first preliminary design for these girders had been made from influence lines determined by the method of three moments, assuming a constant moment of inertia. This girder was tested for

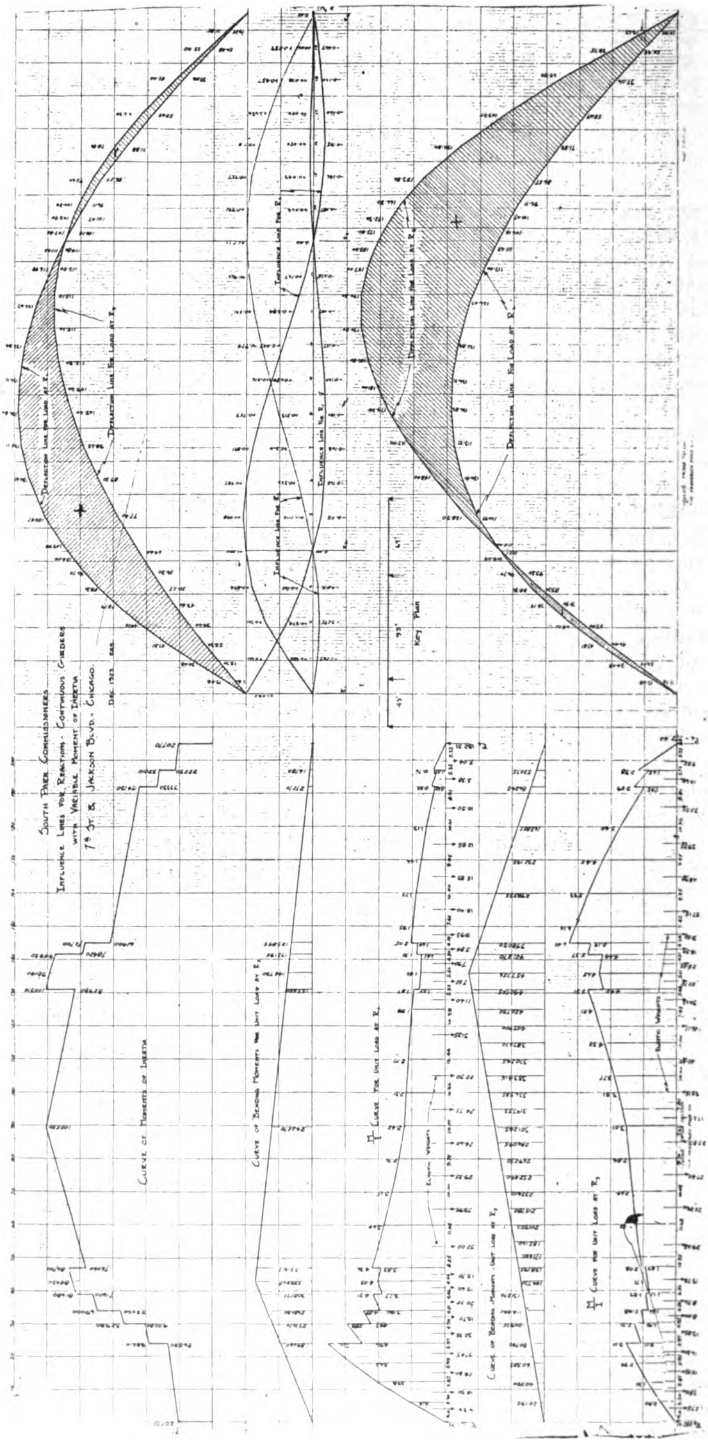


FIG. 3. INFLUENCE LINES FOR THE REACTIONS OF A THREE-SPAN GIRDER OBTAINED FROM THE MOMENT CURVES.

deflection and found to deflect excessively under load. The amount of allowable deflection was based on the City Code which says that the depth of a girder shall not be less than 1/12 the span length, or in the event of a more shallow depth, the fiber stress shall be reduced to such an extent that the deflection will be no greater than if the depth were 1/12 the span. This is equivalent to saying that the deflection shall be limited to 1/725 the span. As the deflection is proportional to the stress an assumed allowable stress was determined for the central portion of the span and the full 16000-lb. per square inch was permitted over the supports.

From this preliminary information we were ready to make the final design. As there are, under present plans, 36 girders to be designed for these bridges, all of the same span lengths and depths, a careful study was warranted. As the maximum "I" was about five times as great as the minimum "I," it was decided to study the effect of variable "I." Figure 3 shows the steps necessary for working out the influence lines for the reactions of a three-span girder with a variable moment of inertia.

The first step in working out these reaction influence lines was to construct the "I" curve for the entire girder. Next the two interior supports called R2 and R3 were removed and with a unit load placed at R2 on the simple span, R1-R4, a moment curve was drawn. This process was repeated for a unit load at R3. By dividing these two M curves by the I curve the M/I curves for unit loads at R2 and R3 were obtained. The bending moment at any point on the simple span R1 and R4 with the M/I curve considered as a load, gave the ordinate to the elastic curve at that point. A series of these ordinates was obtained from each M/I curve and the resulting curves platted giving as a result, two elastic curves; one for a unit load at R2, called Curve 2, and one for a unit load at R3 called Curve 3. The ordinates to Curve 2 were changed proportionately so that Curve 2 and Curve 3 intersected at R2 and the ordinates of these two curves subtracted, gave as a result the influence lines of R3. This influence line for R3 was reduced to scale by dividing each ordinate by the ordinate at R3. This process was repeated, making Curve 2 and 3 intersect at R3 to obtain the influence lines for R2. After obtaining the influence lines for R2 and R3, the influence lines for R1, and R4 were obtained by the principles of statics.

This method has slight inaccuracies if the ordinates are scaled, but when these curves are laid out to a large scale, it it the writer's belief that these inaccuracies are negligible. If possible, the better plan is to get the ordinates to the elastic curves at the same points for both reactions and then subtract them arithmetically. This method will work out very well with either two or three spans, but with four spans the amount of work and the accuracy required, makes the method prohibitive unless it is absolutely necessary to take account of the variable I, which condition would be rare.

In the writer's opinion, the method of influence lines is the best for working out continuous girder designs. In the first place different girders for the same bridge carry different loadings and after the influence areas are worked out it is merely a matter of multiplication to obtain the various moments desired. If for any reason it is necessary to add concentrated loads, it is a simple matter to arrive at the desired results. Also at certain points the maximum moment is given by broken loads and it is impossible to obtain these loads without influence lines. Consequently a curve of maximum moments can be constructed that will be different than if unbroken loadings are applied. Again for street car concentration, influence lines can be used to advantage.

As deflection is one of the ruling features of design, a study was made of the final girder. Figure 4 shows the deflection studies for the center and east spans of one of the girders for Jackson, and Seventh Street bridges.

A moment curve was laid out for a load, giving the maximum deflection for the span and from this M curve and the I curve for the same span, the M/I curve was obtained. The curve of tangential deviations obtained by platting the statical moments of the M/I curve taken about each end of the span up to some point near the center of the span. It

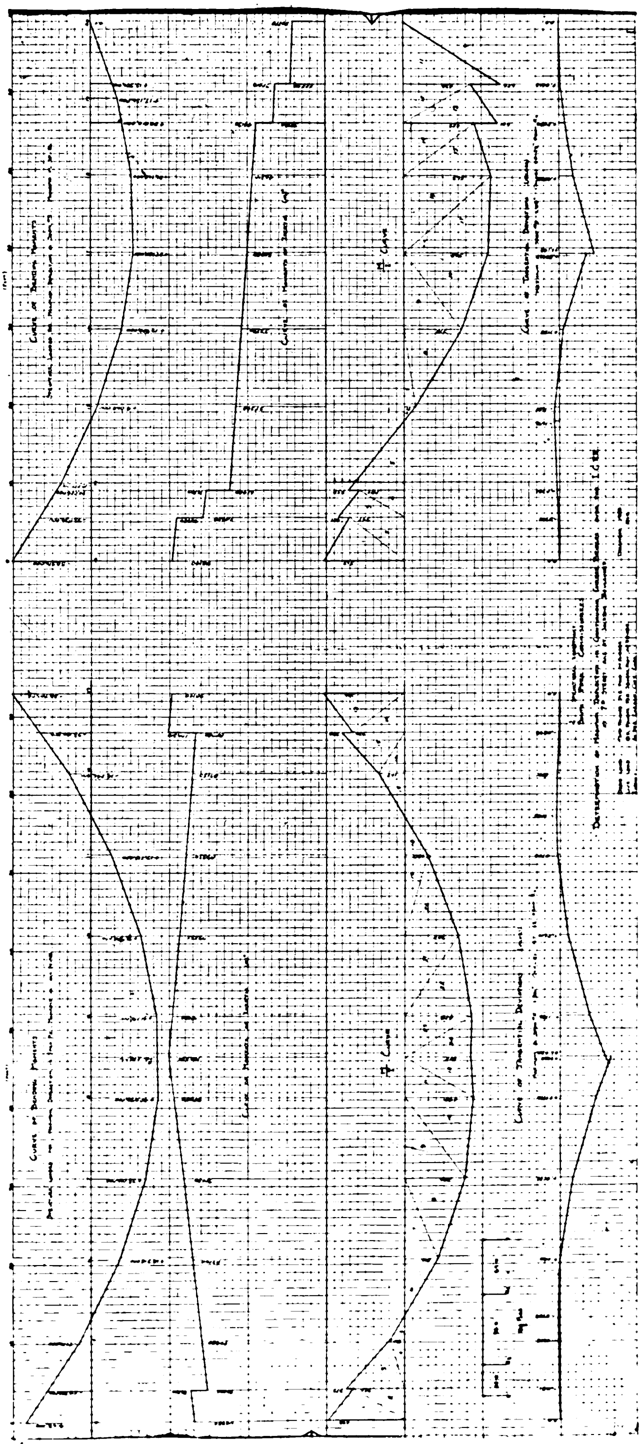


FIG. 4. DEFLECTION STUDIES FOR CENTER AND EAST SPANS, JACKSON BLVD.

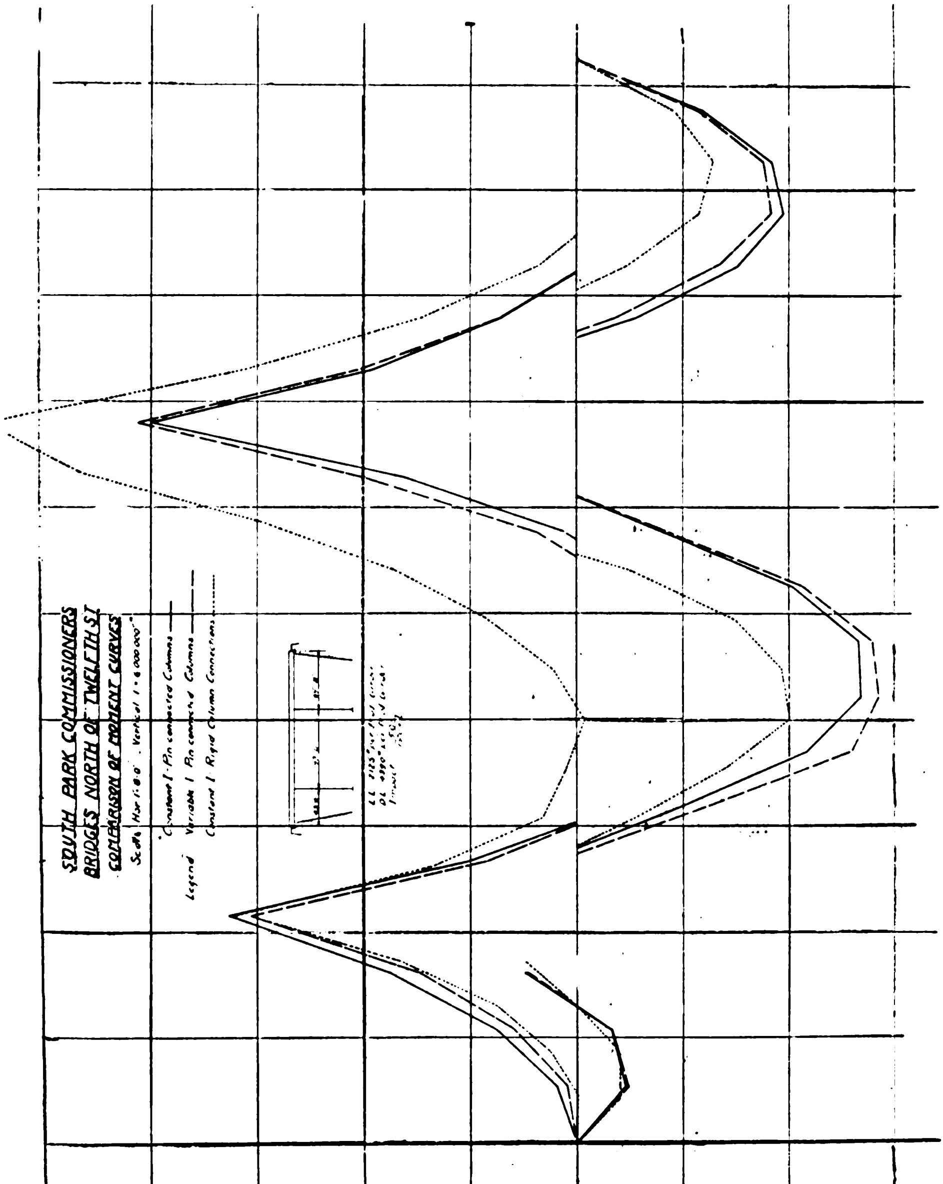


FIG. 5. COMPOSITE CURVE SHOWING COMPARATIVE MOMENTS UNDER DIFFERENT ASSUMPTIONS.

was found that the maximum deflection and its location were given quite accurately, by the intersection of the curves of tangential deviation.

For three reasons the columns should be rigidly connected to the girders if possible. First, it had a tendency to reduce the deflections in the long span, second it made fixed connections to the abutments unnecessary, and third there was no joint necessary between the columns and girders after encasing in concrete. Influence lines were worked out considering rigid connections at the

junction of column and girder, and assuming the column fixed at the base. These influence lines were made by the method of "Slope Deflections." To arrive at the moment of inertia to use for the girders, the deflection of the girder was found under load, taking into account the variation in the I and then working backward, a constant I was found for the span, which would give the same deflection under the same loading. This new I was used in the "Slope Deflection" computation.

Figure 5 is a composite moment curve or one girder showing the relative moments for the same loading with the three different assumptions, i. e. first the constant I and pin connected column; second the variable I and pin connected columns; and third fixed column connection. The variable I and the constant I curves are nearly equal and under ordinary conditions an investigation of the moments due to a variation of the moment of inertia would not be warranted for plate girder design. The fixing of columns to girders has a material effect on the positive and negative moments, greatly decreasing the positive moment and increasing the negative.

All girders were designed by the net moment of inertia method because of long spans, shallow depths, and the consequently heavy flanges. In general the unit stress used was 14,500 lb. per square inch between supports and 16,000 lb. per square inch at the supports.

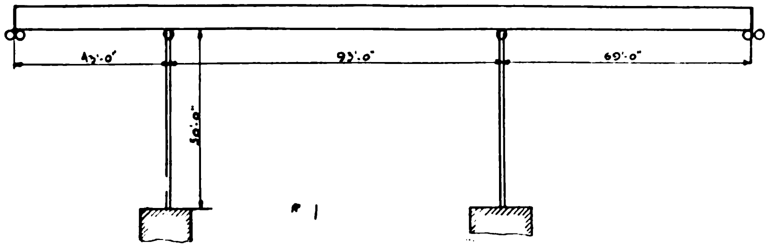
The question of column design was quite a problem. The Illinois Central Railroad Company expects at some future date to double-deck its tracks through the area over which the South Park Commission is building these new bridges. This meant that the columns had to be about fifty feet in length. On the upper level the South Park Commission was to use not greater than 24-in. columns, except in special cases and, for the lower level 34-in. columns were the maximum size, measured in an east and west direction, outside of concrete cover. This length with its reduced fiber stresses and limited width, in some cases as low as 18 in. outside of concrete, made it impossible to take care of the moments caused by fixing the columns to the girder and eliminated the fixed column design.

Five other possible column designs were then investigated. These five designs are shown in diagrams. Case 1 assumed the columns to be fixed at the base and pin connected to the girder, and the girder free to expand over each abutment. In this case the columns took all the tractive, temperature and eccentric forces. This required columns entirely too heavy and Case 2 was tried. This case is the same as Case 1 except that the girder is pin-connected at the east abutment. This was the case used in the final design with the exception that the girders were fixed at the west abutment for Seventh, and Jackson Streets only.

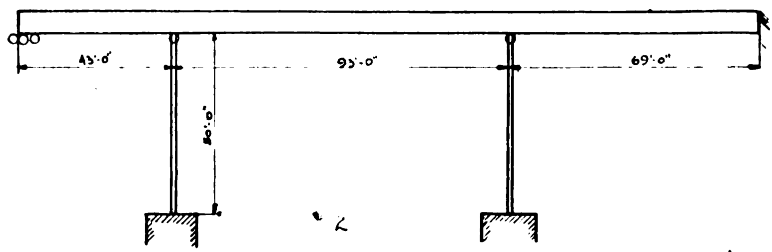
Temperature stresses in the columns could have been reduced by fixing all the bridges at the west end due to the shorter west spans, but because of a ladder track arrangement of the Illinois Central R. R. certain columns in the east bents of Congress, Van Buren, and Harrison Street bridges were narrowed to 18 in. outside of concrete cover. To avoid cutting in on the clearance diagrams, it was necessary either to build transverse cantilever girders to carry the exterior bridge girder out over the tracks or to reduce the size of the columns to 18 in. The reduction in the width of the columns where such long lengths were necessary was thought inadvisable until a design was made using the cantilever transverse girder. With this design simple main girder spans were required and the cost of steel for these simple spans increased 70% over the continuous design. Consequently the narrow columns were resorted to. In order to reduce the stresses in these columns to allowable units the girders were fixed at the east with the exception of the two bridges aforementioned.

As the columns extend some twenty-five feet underground, Cases 3, 4, and 5 were developed with the idea of bringing a concrete column up to about the ground line, but increasing it in width to 34 in. Case 3 was similar to Case 2 with the exception that the lower portion of the column was constructed of concrete. In this case it was impossible to get a concrete column strong enough to take the loads and moments.

Case 4 was the same as Case 3 except the location of pins was moved from the underside of the girder to the junction


43'-0"
93'-0"
69'-0"
30'-0"
#1

CASE 1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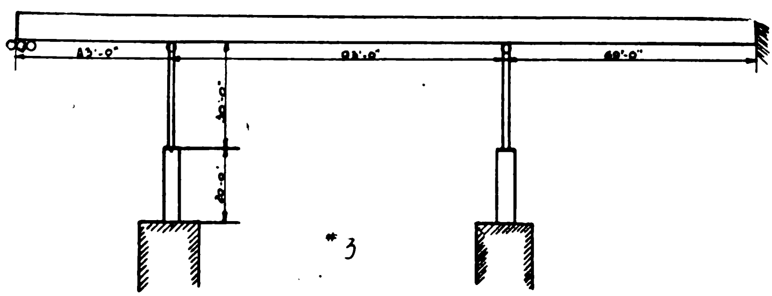
#2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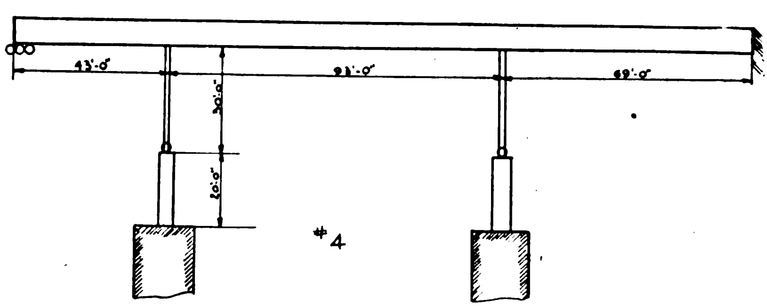
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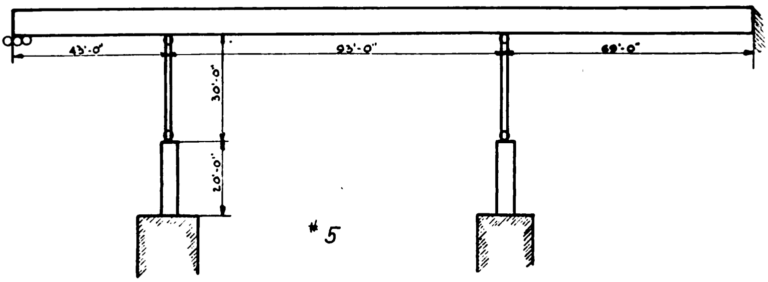

CASE 5

of the steel and concrete columns. This case required columns entirely too heavy to be economical, and also brought in the undesirable feature of a pin at the ground line.

Case 5 was the lightest design, combining Cases 3 and 4 but the additional cost of castings offset the saving in steel. Cases 4 and 5 had similar disadvantages in that a pin was located at a point hard to conceal and which was undesirable for architectural reasons; also these pins would then be in a position to collect dirt. It was also unwise to have these pins just below or just above the collision wall.

In cases 3, 4, and 5, there was an uncertainty of obtaining good concrete because the columns were narrow and heavily reinforced, with stresses running high enough to necessitate a rich concrete mix. The cost of all designs was found to vary but little from the original design with the short columns and caissons brought up to present ground level.

The original design contemplated placing two columns under every girder, but this interfered with the Illinois Central Railroad Co. loading and unloading trains at the station platform, so that a wide space of columns was desirable at some points. A study was made to determine the difference in cost between using columns under every girder in each bent, or using a combination of columns and transverse girders. It was found cheaper to cut out about one-third of the columns in each bent because of the cost of caissons and that cost of caissons omitted would more than pay for the transverse girders. Figure 7 shows the transverse girder design for Jackson, and Seventh Street bridges.

There are two interesting features in the design of these transverse girders. The first is in the expansion and contraction of the main girders. Instead of transferring this stress directly to the columns, it is transferred to the transverse girder and carried to the column. The transverse girder had to be designed to carry this load in cross bending and torsion as well as the direct load. The vertical reaction from the transverse girder is carried into the brackets and the cross bending by the end stiffeners into column.

The second feature was the deflection of these girders and the effect on the main girder. The maximum deflection under the load considered, in any of the transverse girders was ¼ in. and instead of cambering the girder an additional ¼ in. thickness was added to the sole plate supporting the bearing casting under the main girder. The load used was that which gave maximum positive moment in the center span of the main girder, for it was considered advisable to compensate for the deflections in this span.

Figure 8 is a typical cross-section through one of these bridges, showing the encasing details for columns, girders, etc. Section "EE" shows the method of hiding the pin connection between column and girder. This drawing also shows how far below the ground line the base of column is located. The collision strut is made of structural steel in the shape

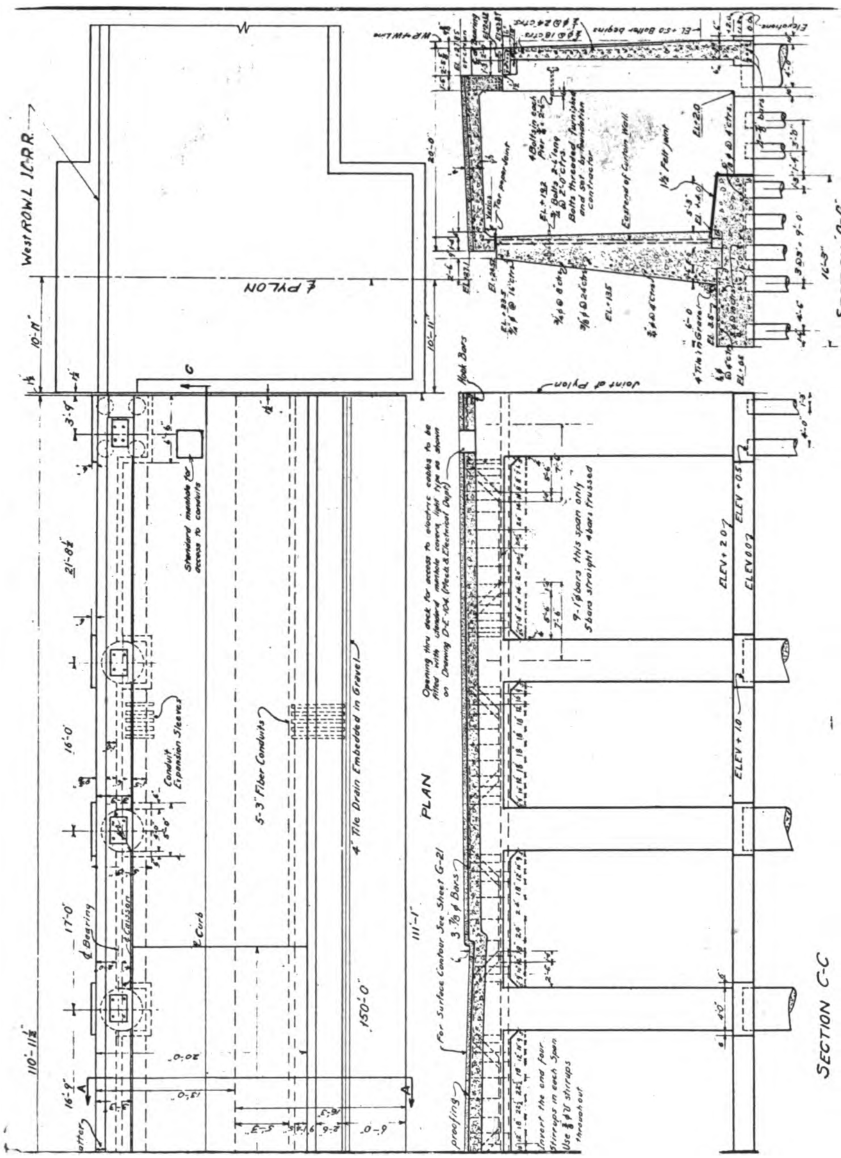

FIG. 7. CROSS SECTION SHOWING TRANSVERSE GIRDERS.

of a lattice girder, substantially encased in concrete. All bolsters and pin connections are encased in monel metal and filled with a bituminous substance to keep all water and dirt from entering. This material will have a low cold test, a high volitalizing temperature and high melting point; to prevent injury to either castings or discoloration of concrete.

There are several interesting details in connection with the design of the bridges north of Twelfth Street as shown in Figure 9. One of these is the rigid column connection to an exterior girder. A heavy gusset plate is spliced to the cover-plate of column, and connected to the girder with horizontal I beams and vertical diaphragms. Then a heavy plate

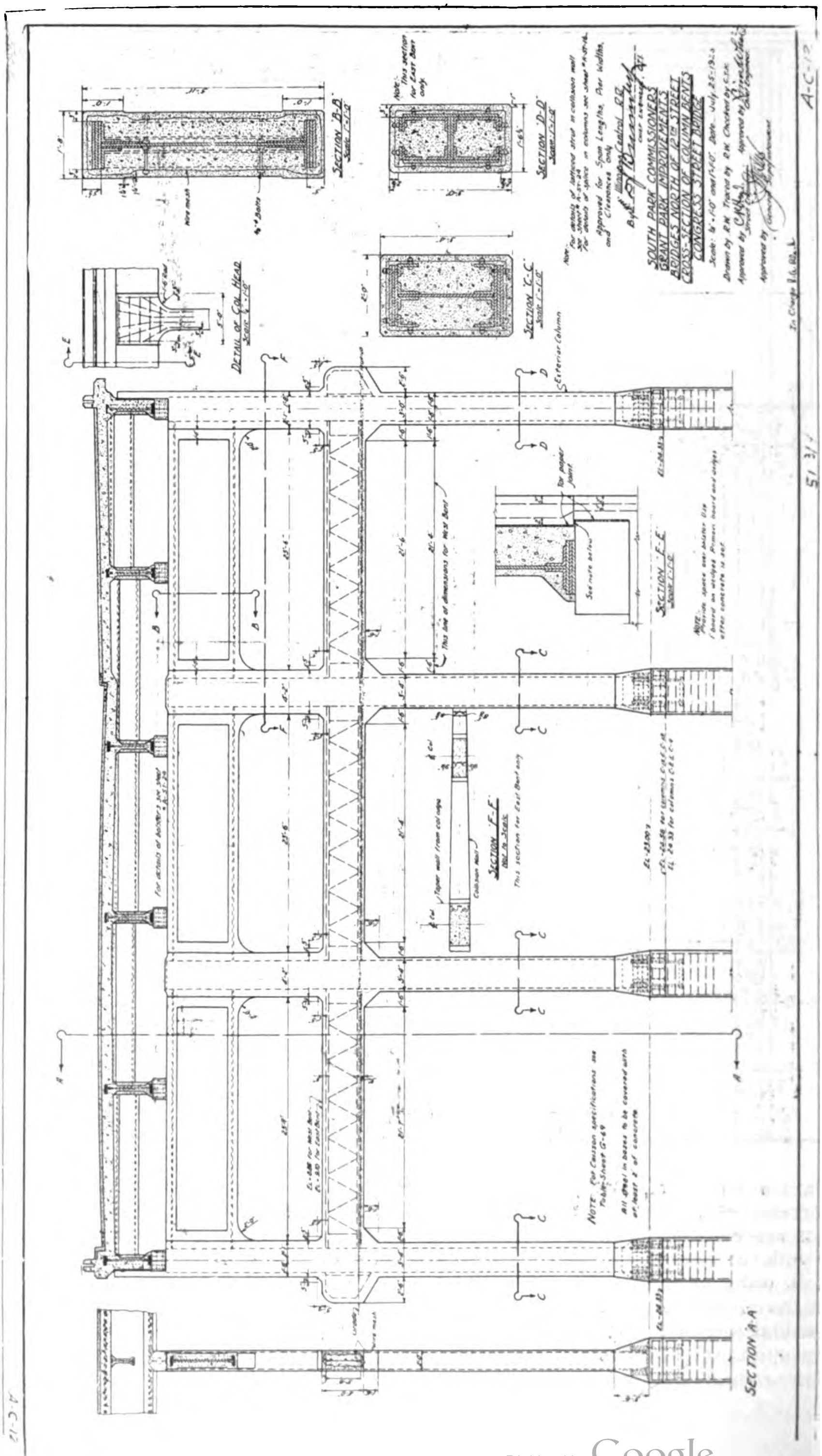

FIG. 8. TYPICAL CROSS SECTION SHOWING DETAILS OF CONCRETE ENCASEMENT.

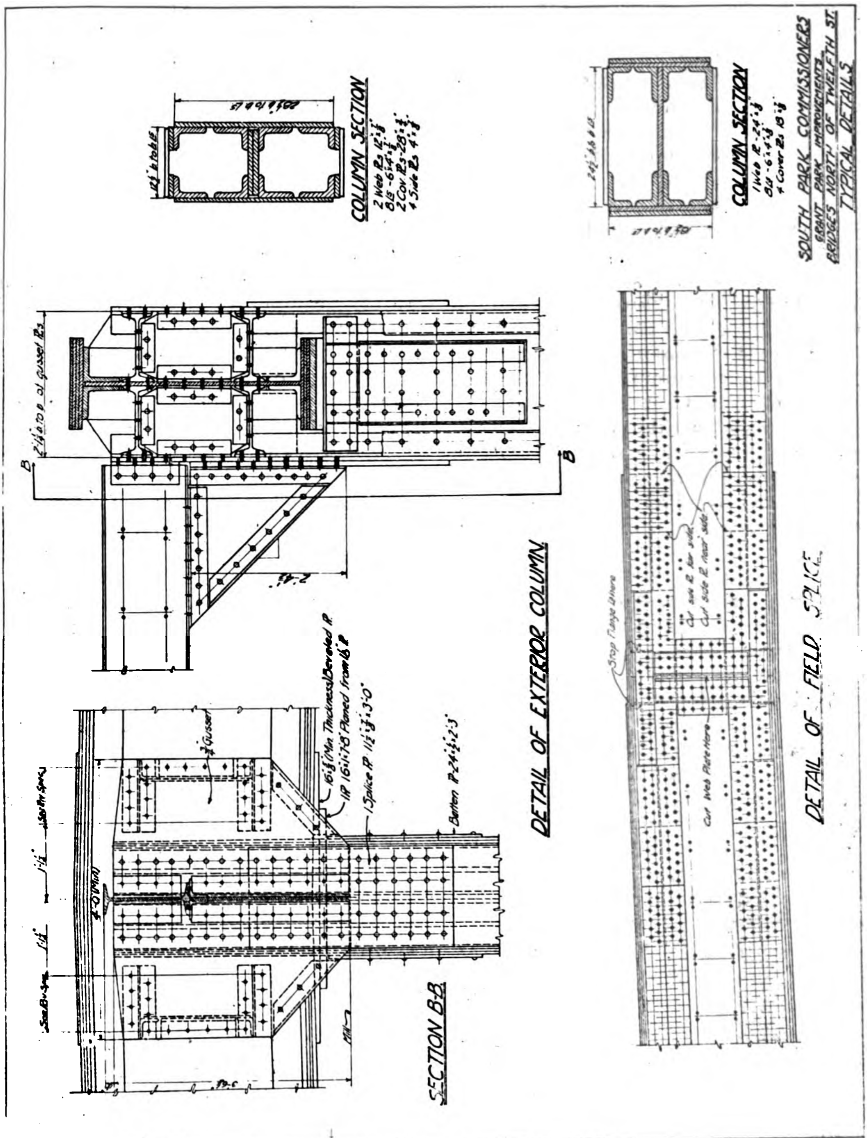

FIG. 9. CONSTRUCTION DETAILS.

diaphragm connects the extended angles of the column to the stiffener on the girder. A heavy bracket under the I beam helps to act as portal bracing between columns.

The field splice in the girder is unusual. As a rule a field splice can be located at a point of minimum moment but with a shallow girder and at a point where a break in the slope of the girder flanges occurs, quite a complicated detail results. The flange plates in general were spliced by the next plate above; the top plate splice being taken care of by extending a cover plate beyond the theoretical point of cut-off to supply the additional metal required. The web plate was spliced by a plate full depth and of

the same thickness as the flange angles with a filler of the same thickness as the side plates under the web splice. This meant that the flange angles had to be cut either side of, and spliced over the web splice plate. The side plates were then spliced either side of the web splice, near side and far side splice being staggered within close limits.

In the lower right hand corner of Figure 9 is shown a typical column section that has worked out well for the slender columns and above it is a section showing the type of column used where extremely narrow dimensions were necessary. This latter column had an "l over r" equal to 110 and is the narrowest in use. It is used as the exterior column in the east bent of the double Congress Street bridge, and in the east bent of the bridges at Harrison and Van Buren Streets, two of them being required in each case.

Figure 10 shows the west abutment for Congress Street bridge. This design is typical for all the bridges north of Twelfth Street. Section "AA" shows a cross-section through the abutment which was developed with the idea that the ends of the continuous girder should have a bearing to rock and consequently should be on caissons, as the whole area is filled-in land and in the event of the Illinois Central R. R. double-decking its tracks, a settlement might occur to any other type of foundation. These caissons were reinforced to take temperature and tractive stresses from the bridge, but it was impractical to attempt to carry the earth thrust from the fill into the caissons so relieving walls on piles were designed to take all this earth pressure. The retaining wall is entirely isolated from the caisson foundations by expansion and settlement joints. Any slight movement of the retaining wall cannot throw unexpected stress in the caisson foundation.

In conclusion I wish to bring out the following facts:

First. Where good solid foundations can be secured without greatly increasing the cost of construction, the continuous girder bridge will be found to be much more economical.

Second. A study of the continuous girder considering the variable moment of inertia is not warranted for ordinary design.

Third. Fixing the columns to a continuous girder will materially decrease the deflection because of the restraining action of the columns.

It might be interesting to note that in the contracts about to be let at the present time, for the construction of the foundations for all six of these bridges, and the fabrication and erection of the structural steel for Jackson and Seventh Street Bridges, the following quantities of material are required:

11,000 cu. yards of reinforced concrete,
550 tons of reinforcing steel,
1,600 tons of structural steel,
40,000 yards of excavation,
99 caissons;

all for a total cost of approximately $800,000.

DISCUSSION

C. H. Mottier, M. W. S. E.: Questions may arise in the minds of some as to why the 3, 7 and 5 track arrangement. The spans, reading from the west side, provided for a three-track space, a seven-track space and a five-track space. The cuts did not show the tracks. The original bridges that Mr. Hoyt referred to have all been wrecked now excepting the Eighth Street Bridge, but they provided for five 3-track spans. That would be 15 tracks. In working this arrangement out with the South Park Engineers, and keeping in mind that the Illinois Commerce Commission had given permission for a 13-ft. track center, we could not get a 200-foot right of way and allow for four 2-ft. posts. We worked out a compromise arrangement with two 2-ft. columns, and then worked the track centers down to 12 ft., 10 in., and we have obtained permission from the Illinois Commerce Commission to use those plans. By having the 3-track arrangement on the west, it naturally kept the thickness of that span down to a minimum, which helped the grade off Michigan Avenue also, and also had a bearing in the track arrangement at Van Buren Street, because that column of the

new stairs that were opened a week or two ago, the columns come in the platform space, so we are saved the extra clearance that we have from track centers. The platform arrangement requires only side clearance of about 5½ ft., whereas we have to have a 7-ft. side clearance from center of track to column, so we use 1½ ft. in the platform space.

Some of you probably wonder why it is necessary to have those thin columns at Congress Street. Van Buren Street is on the North, the two Congress Street bridges and Harrison Street on the South. The Railway Company is interested in getting a double No. 8 ladder, 16-ft. centers, through between those two columns. The two bridges were too close together to get the columns through so we asked the Commissioners to cut a little off the columns. By using the narrow columns, there was just enough space to get the double ladder through between them. We did not want to tie up the track arrangement in any place between any streets, so we could not get a double ladder through.

W. G. Arn, M. W. S. E.: Mr. Hoyt mentioned the two rows of columns. We are going to need more space down there. We are very much cramped down there already. In fact, we had a great many discussions with the Transportation Department before we got them to agree to give up the room needed to put in even the two rows of columns. Some day we expect to need additional tracks. The only place for them is below because of the city ordinance which prohibits any structure extending upwards above the top of the retaining walls.

H. E. Eckles, M. W. S. E.: I noticed near the first part of the article, a statement that the fact that the columns were fixed to the girders made a very substantial difference in the moment of the girders. Later on the design was changed to pin connections at the top. I would like to ask Mr. Hoyt if he found a very material difference in the cost between those two.

Mr. Hoyt: The actual change in weight of the girder is not so very material. The fixed condition reduces the deflections somewhat and due to the reduced deflections a higher fiber stress can be used. That higher fiber stress is the principal saving in the material of the girder.

Mr. Eckles: That was the point I was interested in especially, and there is a great difference in the effect of relative moment of inertia in the columns. Since I saw the first diagrams the columns were changed quite a bit. The heavy columns made a great deal of difference and the columns were in some cases reduced to 18-in. That presented a different proposition. I noticed the pins were omitted from the bottom of the column and some other conditions were brought out.

Mr. Hoyt: There are some other conditions, in that the pin connection at the base of the column was very objectionable from the architectural standpoint. As I tried to show, the pin connection at the top of the column could be very effectively hidden by means of a fin running up from the column and in front of the pin connection. A pin connection at the base, if it were below the collision wall, would gather dirt, and although it would be adequately concealed, it would be hard to get at and expensive to inspect and to fill with the material which we intend to use for preserving the pin. If placed above the collision wall it presented a very undesirable architectural appearance. With the amount of money that is being spent around Grant Park and in that vicinity for aesthetics it seemed advisable to eliminate the pin from that point. Also, a pin below the collision wall would be a point of weakness, in my opinion, in case of a collision between a train and bridge.

T. L. Condron, M. W. S. E.: I have been very much impressed with the idea of getting these long spans carried on a slender column as Mr. Hoyt has succeeded in doing, and I should be considerably interested in the analysis that would lead up to that result. I think the Illinois Central rather narrows down to pretty slender columns myself, but we know what the conditions are in that very valuable right of way. I did not quite understand what Mr. Hoyt said with reference to the elimination of a pin at the bottom of a column for aesthetic reasons.

Mr. Hoyt: We could have used Monel metal the same as at Twenty-third Street. We thought down in that location that if it was possible to eliminate the pin at the base it would have a little better appearance aside from the other reasons which I gave. Of course, it might have been possible to bring the collision walls up to such a height as was done on Twenty-third Street viaduct. But we felt, after the drawing up of the bridge, that it would be preferable to eliminate such a high wall. The high wall also had an added disadvantage in that the wall would have to be levelled off considerably away from the column, on account of the Illinois Central track clearances, while with the low wall it was below their clearance lines.

Mr. Mottier: They didn't have any wall at all at Van Buren Street. The wall came at the platform so they decided to abandon the collision wall.

Mr. Hoyt: That was one point where we did put pins in the top and bottom of the columns, because of going up through the top of the Illinois Central suburban subway, this made it impractical to carry a column to take flexure down through their subway without causing some leakage around the column.

A. R. Mitchell, M. W. S. E.: In the design of these columns, did they consider the question of second story tracks or are they to be carried independently?

Mr. Hoyt: The second story or roof of the I. C. subway is to be carried entirely independently of our columns.

Mr. Mottier: Mr. Hoyt showed you the picture of the West abutment and the piles, of course, allowing for an angle of repose in the earth would keep the pressure pretty well off the caissons in the West right of way line. In working the plan out we told the Commissioners that we would be satisfied with two tracks—I am speaking now of the lower level—on the West span which has three tracks above and six tracks in the middle, which has seven above and four on the East, which has five above, and with that arrangement we keep well away from the right of way lines, and at the same time give them added thickness for the columns and allow for 2-ft. walls, I think it is, between each pair of tracks, so we get a regular box construction.

G. Jeppesen, M. W. S. E. Could you not connect these columns by struts in an East and West direction?

Mr. Hoyt: Not very readily, because the Illinois Central, I believe, would not want to go any deeper with their subway than necessary. I think they want to get the last inch, and a strut 93 ft. long between the center columns would be of such enormous length and would have to be very large in order to be of any value whatsoever.

Mr. Mottier: The Commissioners would not have had independent structures because the strut would have to carry a track load, from the upper track.

The Problems of Federal Reclamation

By Dr. Elwood Mead*

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One branch of the Federal Government that concerns us as citizens and engineers is the Reclamation Service which is bringing arid lands under cultivation. Due to lack of proper consideration of the purely economic features in many cases, the engineering works have fallen into disrepute. Dr. Mead has attacked this problem on the broad basis of economics as shown in this able paper.—Editor.

OPPORTUNITIES for home-making on the public lands of this country have been the greatest single influence in shaping our national character. Free land was the beacon of hope that attracted the hardy and adventurous from the hills of New England and from the farms of Germany, England and the Scandinavian countries. The voice of opportunity called and found a response in the energetic, self-reliant and ambitious.

This westward march of settlement continued without interruption until it reached the borders of the land of uncertain and scanty rain. There it halted because it encountered obstacles that individuals working alone could not overcome. Up to that time the creation of homes had been an individual matter. The pioneers believed that every man should hoe his own row and take care of himself. It created a confident and hopeful people but made them migratory and speculative. The pioneer was not a good farmer. He was ready to move on when there was a chance to sell out at a profit, and gave little thought to the needs of the rural civilization he was helping to create.

The development of irrigation requires a different attitude. It imposes laws of its own which must be observed. People who live under irrigation canals must cooperate. They are bound together by their common tie of dependence on the stream. Protected by irrigation from the uncertainties and vicissitudes of rainfall, that insurance has to be paid for. They have to level their fields so water will flow over them evenly. They have to pay large assessments to maintain and operate these works. To meet these charges the irrigator has to be a skilled cultivator; only the good farmer permanently survives. The best cultivated farms on this continent are in irrigation districts. Those around Greeley, Colorado, rival those of the Lothians in Scotland.

Whether he likes it or not, the farmer under irrigation has to lose some of his freedom. He must keep step with his neighbors and irrigate when his turn comes. This means that plans must be made in advance and a kind of organization adopted that the farmer who depends on rain can ignore.

The pioneer settlers of the arid region did not at once realize the profound change which irrigation would enforce. They gave little thought to the institutions they must adopt. For a time they were able to work and think as individuals. By means of a simple plow furrow they turned water from streams over the thirsty soil of the low-lying bottom lands. But opportunities for this kind of development were limited. Soon the bottom lands had been filed on, all the cheap ditches had been built.

Then it began to be realized that if the magic touch of water was to bring into fruition the latent agricultural wealth of this inland empire, a different and much costlier type of irrigation work had to be brought into being. Reservoirs were needed to hold back the floods, costly aqueducts had to be carried through precipitous mountain canyons. Only in this way could orchards and gardens be planted and homes made on the better soils of the higher plains.

These great structures cost more money than single settlers, or even organizations of settlers could provide.

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The capital required soon went beyond the means of corporations. Finally, about the beginning of this century, it was realized that only the Nation or the states had the credit and the reserve of resources needed to bring into existence the monumental structures required for the complete conquest of the arid region.

The reclamation act passed by Congress in 1902 was the outcome of this new and broader conception of the future of irrigation. It set aside the proceeds from the sales of public land; later on added to this, half of the money coming from mineral leases, to create a fund with which to build irrigation works. This fund was to be augmented further by the money received from water users in payment for irrigation works. These payments were to be made in installments extending over twenty years. No interest is charged on deferred payments. Water users pay the equivalent of 5 per cent interest for twenty years and get the works as a gift. Other governments donate a part of the cost of important works but none build them without charging interest.

The act has been in operation for twenty-three years. About $160,000,000 has been spent on construction. The repayments have been disappointing. On only one project has even half of the cost been repaid. On some, settlers have paid nothing on construction and are in debt for much of the cost of operation.

In its agricultural aspects, dotting the unpeople areas with homes has brought large returns. The crops grown in 1924 on 24 projects were worth $66,488,560. One hundred and forty-three thousand people live on the irrigated farms and an additional 337,000 in project towns and sites. When all the farms are occupied there will be from 15,000 to 20,000 more. Reclamation has done much to save some arid states from economic collapse. The situation in Nevada would be critical if it were not for the Newlands project. Counting those who live on this project, the state has only 70,000 people. This little handful of citizens supports government, schools, courts and higher education over an area larger than the state of Illinois. Without the Newlands-project farms with their winter feed for range stock, it is difficult to conceive how this state would carry on with its shrinking resources in mines and forests.

Western irrigation areas are now our main source of long staple cotton. Millions of dollars which now go to the irrigation farmers of Texas, Arizona and California would, without Federal reclamation, go abroad to the cotton growers of Egypt. Without the local fodder crops of irrigated farms, the range livestock industry of the arid West would collapse. These Federal projects have given an economic support to cities that sorely needed it. They have increased the business of transcontinental railroads, furnished markets for the products of factories and contributed far more to the economic strength of this country than is realized in the humid sections of the country.

But along with these achievements, which have gone far to justify the Government's activity in reclamation, there has gone a tragic waste of money, effort and opportunity, because the problems of finance, of farming and the human needs of settlers have never been adequately thought out nor plans made to meet them. Lack of economic and social plans has wrecked some projects and has created the problems that the Interior Department and Congress are now seeking to solve.

The Larger Conception of Reclamation

Congress realized at the outset that reclamation requires money and skilled engineers. These were provided. It was not realized that money and expert advice and direction in changing the sagebrush deserts into farms would be needed; these were not provided. It was not realized that to repay these immense costs settlers must be skilled cultivators. Their selection and training were ignored.

If reclamation is to go on we must now provide for meeting these human and economic needs. Only by doing this can the monumental enterprises now being pressed on the government be made a success.

The irrigation works of the Columbia

Basin project in Washington will cost nearly $200,000,000. The water right for a single acre will cost $158. To that must be added the cost of changing raw land into farms, which will average $100 an acre. The Colorado River now irrigates 2,000,000 acres. When all its waters have been conserved and used, it will irrigate 6,000,000 acres. The agricultural development of these two valleys will cost more than a billion dollars. Without skilled farmers working with good tools, owning good stock, and using science and skill in cultivation, the money spent on construction will be thrown away. To make these costly works pay, there must go with them an agricultural and rural civilization as far removed from that of the covered wagon, as that of Denmark is from that of Central Africa.

It is a task worthy of our ablest minds, one of the greatest which ever challenged the ability and patriotism of this Republic. Let us, therefore, undertake to appraise some of its requirements and follow the evolution of the last quarter of a century, in order that we may understand what has been achieved, what mistakes have been made, and what tasks confront us.

We Should Profit from Past Experience

To begin with, Federal reclamation can not succeed unless it is divorced from politics. Less attention in the future must be given to local importunities. This means disappointing some states which desire the expenditure of a share of the fund within their borders, regardless of the cost or what the results will be after works are built. From the first Western Congressmen have been subjected to strong local pressure to get works built and afterwards to relieve settlers from their payments. The high construction costs of today render it imperative that hereafter reclamation be freed from all danger of political control.

The reclamation policy was founded on the theory that if irrigation works were built, settlers would flock in and in some way dig in and succeed as they had on the prairies of Iowa and Kansas. The difference between the conditions which confronted a homesteader in Iowa, where a paying crop could be grown the first year, and in Arizona, where the land had been baked for centuries, and where after costly preparation a year or two of unprofitable watering and cultivation would be needed before good yields could be obtained, was ignored by these beginners.

The settler in Iowa could begin as a farmer, doing farm work. The settler on a reclamation project has at least a year's work that is not agriculture but engineering. He confronts a tract of unleveled, unfenced sagebrush. Before he can grow a crop he has to have a shelter for his family and his work team. His land has to be fenced to keep out range cattle and sheep. The inequalities of the surface have to be smoothed off so that water will flow over it evenly. For a beginner, this is hard and discouraging work. It requires tools that the farmer from the East has never before seen. It requires a peculiar knack and skill to do the work properly and it is often enormously expensive, costing as high as $75 to $100 an acre. The settler sees his savings eaten up doing unproductive work, and when his capital is gone, he has to succumb.

A majority of settlers on these projects did not know what crops to grow or when they should be watered. All the conditions were strange and new to them. If these harassed farmers could have been organized so that their efforts could have been combined and they could have touched elbows in preparatory development, its influence in keeping up their morale would have been invaluable. Working alone, without practical advice or direction, much that they did was done at a disadvantage.

The Problem of Collection

Lack of aid in farm development has burdened inexperienced settlers on these projects with heavy private indebtedness and caused thousands of mortgage foreclosures. This has demoralized reclamation finances. The unpaid assessments for construction and operation for the five years from 1920 to 1924, total $8,-500,000. This was increased in 1924 by over $3,000,000. Some of the projects

during that period have paid practically everything they owed. Some had paid practically nothing. In some cases failure is due to unfit lands. No matter how hard the settler works, he can not earn the money to repay project costs. On others, a policy of drift has caused good projects to remain undeveloped, the fertile soil uncultivated.

The Lower Yellowstone project in Montana is an example of the latter type. It needs only good farmers working on small farms to make this as good an irrigation project as those around Salt Lake and Denver. Owing to the fact that a large part of the land is held by speculators who are not farmers, only 14,000 acres out of 58,000 acres in the project were irrigated in 1924, fifteen years after water was first supplied. Some of the unirrigated land is dry-farmed, there being enough rain to grow small grain; some is still covered with native grass. If these owners had been real irrigators, desiring to farm, no compulsion to irrigate would have been needed, but under a system which opened the land to settlement to the fit and unfit on equal terms, communities were gathered together, here and elsewhere, many of whose members knew nothing of irrigation farming and never intended to become farmers.

On another project which we are trying to salvage, I recently went over the list of occupations of the early settlers. The first was a deep-sea diver, the next was the wife of an itinerant baseball player, the third had been a missionary in China. A defunct bank owned several farms. A painter, a plumber, a carpenter, all living in distant cities, owned farms, all unoccupied and untilled. A transient trained nurse had invested her savings in one of these speculative temptations. She had neither the money nor inclination to do more. None of these people have paid water charges or delinquent county taxes for three to five years. Creation of a great agricultural community or the solvency of an irrigation project can not be secured with this kind of human material. On projects like this the fundamental problem is to get real farmers to replace these derelicts who have given up hope but linger on, like Micawber, waiting for something to turn up. In one neighborhood there are 70 abandoned farms and a lack of morale everywhere. If an expert practical committee had selected these settlers and they had been advised about their work, there would now be no important salvage program or possible loss to either settlers or the Government. The deep-sea diver would have stuck to his element, the bank would not have failed.

Water for Irrigation Should Be Worth Its Cost

The fundamental question of all future projects ought to be, will the productive value of the water in irrigation be worth what it costs to provide it? This is far more important than it was twenty-five years ago because the costs of construction and of farm development are two or three times as great as they were then. When Congress passed the reclamation act, $25 an acre was regarded as the maximum construction cost which any settler could afford to pay. Even this figure seemed preposterous to the pioneer.

About that time a range cattleman met a settler who had agreed to pay $10 an acre for a water right in a private ditch. He told the settler he could never do it and he might as well end his misery at once by jumping in the river and drowning himself. The cattleman looked on $10 an acre for a water right as a prohibitive price. He had built his own ditch with a plow and a scraper. He cut the logs for his cabin out of the nearby forest. His pole fence had cost him nothing in money. Time and labor with him had not counted, hence going in debt $10 an acre, with payments on interest and principal, was regarded as financial folly, foredoomed to disaster.

When, however, bills for Federal projects were presented to settlers, instead of $25 an acre, the charges often ranged from $30 to $100 an acre. On top of this there was a yearly assessment for operating expenses. Out of this have grown controversies which have embittered the relation of the Government and the water users for twenty years.

No one was to blame. The law was

an experiment. Conditions which would confront settlers were not foreseen. The agricultural and economic needs of reclamation were not realized.

Land Speculation Must Be Eliminated

Another evil of reclamation not entirely foreseen and against which the original law provided inadequate safeguards, was land speculation. This has been a vampire that has done much to destroy the desirable social and economic purposes of the act. The original idea that Government works would be built to irrigate public land, and that this land would be homesteaded free of cost, developed and cultivated by actual owners, has not been carried out. As it has turned out, the act has been largely used as a lifesaver for bankrupt private projects.

The first project begun was in Arizona, where on Salt River the land had been acquired by private owners who had built canals to divert the unregulated flow of the river. They found this would not answer. They had full canals in June and empty ones in August. Agriculture was impossible without a storage reservoir to hold back the floods and deliver water for late irrigation. Financially embarrassed private projects could not build the reservoir. The Government undertook it. Then it was found that the private projects could not raise money to repair and enlarge their canals so they could use the stored water. The Government then acquired the canals. Finally it became a Government scheme, serving land which was in private ownership when the project was authorized. Eastern capitalists held thousands of acres of this land. Speculators also rushed in and bought, at low prices, thousands of other acres.

On all the projects, unwary people attracted by misleading publicity, bought farms from speculative owners at inflated prices. Land sellers told settlers they would have no trouble with water right payments and so induced them to invest their capital in land, and when pressed to pay the Government charges, the embarrassed settlers made recurring appeals to Congress for relief.

Between 1921 and 1924 three bills were passed by Congress authorizing or requiring deferment of payments. These deferments did not aid the struggling settler who already paid his Government assessments. The relief all went to the non-debt-payer. The purpose behind these moratoriums was commendable, but their influence has been demoralizing. They have created a wrong psychology on some projects. They have placed the non-debt-payer in the saddle. They have demoralized the bureau's finances and broken down the morale of the local officials, who have been struggling against heavy odds to keep the projects solvent undertakings.

Believing that blanket moratoriums are an economic evil, I notified settlers in spring of 1925 that hereafter relief, when extended, would be to individuals; and to them only after a showing that the delinquency was due to obstacles they were unable to overcome. That notice has caused the bureau to lead a strenuous life. Applications for individual relief came in this year by the thousands. They had to be examined and reported on in the field, and then scrutinized in the Washington office. In all cases the underlying idea was to give them a sympathetic consideration, but to insist on payments where the Government's generosity was being abused. As a result of this action, hundreds of thousands of dollars were collected where blanket deferment would have resulted in nonpayment.

Financial Conditions on Old Projects Require Conservative Action in Starting New Ones

Financial and agricultural conditions on the older projects require that careful attention be given to all matters which will affect the solvency of new ones. The last Congress made appropriations for six new projects. Their acre-cost is far higher than that of any government works hitherto built, *either in this or any other country*. The estimate costs vary from $125 to $160 an acre. The land is unimproved. Everything needed to make a farm will have to be placed on it and this will cost on an average about $100 an acre. The settler will, therefore, face an investment of between $225 and $260

an acre when his farm is a going concern, and the question is—*Will these farms be in demand by people able to develop and pay for them?* Local people assure us that we need have no fears about settlers or payments. They insist that the farms will be taken and that the charges will be paid, but their judgment may be biased by their passionate desire for development. When these appropriations were under consideration, I appeared before the Appropriations Committee of both Houses of Congress, and stated my conviction that without adequate aid and direction in settlement and farm development, none of these projects would be a success. I stated that it would require from $5,000 to $7,000 to improve and equip an 80-acre farm; that settlers with this much capital would not pioneer, because they could buy improved farms in the East or South.

I believe we must look for settlers who have between $2,000 and $3,000 which is enough to underwrite a loan for completing farm development. I believe if we accept them as settlers and permit them to expend all their capital, we are bound to provide a source from which the remainder of the capital needed to complete farm development can be secured.

An excellent bill for this purpose was introduced in the House and in the Senate by Congressman Winter and Senator Kendrick, respectively. It provided for advances of money from the reclamation fund. It was my recommendation, however, that if this were done, instead of applying the law to all the projects, it should apply to only two or three where it would be treated as an educational measure, as an experiment or demonstration, rather than a definite policy.

The outcome of the discussion in Congress was provision in appropriation legislation for four projects that states should furnish aid and direction in settlement and farm development. On these four projects the state is required to supervise settlement of the land and provide credit for developing farms. None of the States is willing to do this. This is the feature of reclamation which we have thus far ignored, but it is not new in other countries. Aid and direction in farm development are fundamentals of reclamation development in India, Italy, Australia and South Africa. Agricultural development will be advanced by being decentralized by taking it away from the Federal Government. Aid and direction in settlement and farm development is a proper function of the State. Unless it is provided by the State or some other local agency the building of canals should cease. We must not build them for speculative landowners. Helping men own farms has changed Denmark from a land of discouraged impoverished tenants to a teacher of agriculture to the rest of the world. That comes from having 90 per cent of the land cultivated by owners.

An act passed by the last Congress requires that hereafter there shall be a thorough soil survey of the lands of each new project; that the land shall be classified according to earning power and that annual payments for water right shall be in an amount equal to 5 per cent of the average gross crop return. Recent regulations of the Secretary provide that settlers on public land must have a capital of $2,000 and have had at least two year's experience. This is the first time in the Nation's history that qualifications for settlement have been required. The required qualifications of industry, experience, character, and capital are indispensable to success if we are to build costly works. The inexperienced and those without money would fail, and in the end the loss would fall on the Government.

Fairness to the settler and to the scheme requires that whoever undertakes to subdue the desert and bear the burden of its costs should be fitted for the task If reclamation is to be the chief instrument in building up rural civilization in the western third of our country, it must provide real opportunities for homemakers, give them a lifetime in which to develop and pay for farms and have efficiency and integrity as the watchword in all relations between the water user and the Government.

DISCUSSION

C. R. Thomas: "Land is the easiest commodity to sell and the hardest to buy conservatively that I know," is a remark frequently heard among land men; also, "It is always a feast or a famine in the land business," is another frequently heard remark. Such pat sayings and epigrams often contain much concentrated wisdom which is the product of long and expensive experience.

As the publisher of Reclamation and Farm Engineering and the secretary of the National Drainage Congress during the past two years, I have come in contact with many phases of the land business as carried on in the development and settlement of new land and the sum total of my experience may well be summed up in the two quotations that I have given. This one thing I would add: Anyone who is so foolish as to "sell the farmer short" deserves the same fate that Morgan intimated in his famous remark, "I never sell the United States short." Over a long period of years, almost any land investment will have some period at which the investment may be classed as "good." And land values are so intimately connected with the business of farming that the two must be considered together.

What Dr. Mead has said about the lack of plan in the handling of land settlement applies equally well to many of the private reclamation projects. The engineering problems of reclamation, in practically every case, may be considered as capable of solution. On the other hand, the settlement and social problems of many reclamation projects are, in a large measure, indeterminate in the beginning and introduce an element of risk which varies usually with the *length of time in which it is proposed to "work out" the complete project.*

No project may be considered as completed until all the land is settled by contented, industrious people and the returns from the land are sufficient to meet all of the financial obligations of the farmers on the land. The vast majority of reclamation projects in the United States have been eminently successful. The ground upon which the Monadnock Building stands was once a marsh over which Indians paddled canoes at certain seasons of the year. Northern Illinois in the early days was a vast area of periodically inundated land. The project of reclaiming and settling Northern Illinois may be said to be completed.

But there are many other sections of the country which have begun reclamation projects where the work has not yet been completed. In Italy some projects begun in the time of the Caesars have not been completed and a contract was recently let to an American firm of contractors to finish the physical work of completing some of these projects.

The point is that land reclamation is a term that applies to operations covering a period usually of decades and sometimes of centuries.

The weak point in drainage and irrigation land development as practiced in the past, seems to have been the lack of connection between the various steps in the development—a lack of perspective as the inception of work which must require many years for successful completion. The result of this lack of business foresight has been that many basically sound irrigation and drainage projects have been pronounced "failures" by casual observers because these projects were not immediately profitable.

A similar situation existed among public utiilties not so very long ago. Gas and electric light companies, in many cities were pronounced failures because in many cases, they did not have enough customers to make them profitable. The trouble was often a lack of capital to develop the business that was at hand and would make the utility profitable. To meet this situation and to protect the bond holders, several "work out" organizations were evolved, notable among which was the Byllesby Engineering and Management Corporation. These management organizations attend to the financing, construction and operation of both new companies and those which have become doubtful investments, and by careful management over a period of years safely pilot the utility into the deep waters of steady profits. The results obtained through wise manage-

ment by public utilities "work out" organizations have turned apparent losses into profits for many investors.

Drainage and irrigation projects are usually undertaken by people who own land which they believe will profitably produce crops and which has, therefore, a good sale value. These people seek the advice of engineers who aid them in planning and constructing the improvements. Then the improved property is turned over to a land sales and settlement organization. Up to this point the land has produced no income and bears a heavy burden of taxation, depending upon the cost of the land and the expense of the improvements. Now unless this land is settled rapidly and begins to produce profitable crops on a large percentage of the area, there comes a period when the income from the land is insufficient to pay off the interest and principal accumulated during the improvement of the land. In very few cases has capital been provided in advance to take care of these carrying charges. The cost of the land to the farmer must include the cost of improvements, selling costs, and carrying charges on unsold and therefore untilled land. If the land is sold to people who do not till the soil and produce profitable crops, then the burden of taxation becomes unduly heavy for the farmers who actually till the soil. In few cases have all of these factors been considered together and the entire program of development planned and managed in a closely-knit, continuing manner by a single organization which controlled over a long period of years all phases of the work in a business-like and far-sighted way.

Engineers say they are not to blame for the inability of the owners and the land sales organizations to sell the land and to get settlers to stick to the soil and raise profitable crops. They claim the engineer's job ended when the water was controlled. The land sales organizations say they are not to blame for the expensive improvements designed by the engineers which placed a burden of taxation on the land such that the sales price must be advanced to a figure too high to attract farmers. The owners say they trusted the engineers to develop the land at a reasonable cost and the land sales organizations to settle it rapidly. There is a grand festival of "getting out from under" in too many cases.

We have now reached a point in the handling of land reclamation when a clear conception of the importance of settlement and proper cultivation of the land by competent farmers operating well-equipped farms is absolutely fundamental to any analysis of reclamation problems.

Combined with the development of new land is the intensive utilization of new developments in the art of agriculture. A profound change has taken place in American agriculture during the past decade. Farms are coming more and more to be considered as factories and farming has changed from a business in which a strong back and a loyal family of children with strong backs were chief essentials, to a business in which cash and machinery are the deciding factors in the profit and loss account.

There are fewer farms than there were ten years ago, fewer men on the farms and yet our total production is measurably larger. This is the result of the application of machine power to the farming industry and this application of power is bringing about a revolution in methods centuries old that are as marked as the changes wrought in the manufacturing world a hundred years ago when power was introduced into manufacturing.

For example, the small harvester-thresher is now changing the methods of wheat farming and threshing day on the farm will before long be a thing of the past. The introduction of the light tractor has revolutionized land breaking and tillage, and modern conveniences such as electric lights and power tools for doing the chores are making a different sort of business of farming. The modern farm hand must be a mechanic rather than a horse and cattle wrangler and puncher. He is better paid and accomplishes infinitely more than his predecessor if he knows his business and the farm is properly equipped.

The modern settler, therefore, is a man of means and since he has money, why should he endure the hardships of the pioneering. Settlement projects, therefore, must have roads, schools, a good neighborhood and other conven-

iences that make life pleasant, in order to attract settlers. This means a larger outlay of capital on the part of the promoters and it begins to look as though before many years have past the Government will be the only agency with means sufficiently large to undertake the development of farm land projects on a large scale.

The points just mentioned have but remote connection with the commonly-accepted view of engineering, they involve social and economic problems which are an entirely different kind of engineering. Whether the conventional engineer is equipped by training and inclination to solve these problems, I do not know. But I know of no group of men who are better equipped. It remains to be seen whether engineers have the vision to assume leadership in this important work and the wisdom to recognise the indeterminate nature of the work and not attempt to apply mathematical formulae and methods in their efforts to develop the agricultural phases of engineering, which are rapidly assuming great importance in modern life and thought.

C. L. Seagraves, (A. T. & S. F. R. R.): California wants fifty thousand families to colonize the irrigable lands that are ready today for settlers. I was in Arizona ten days ago. They want twenty-three thousand families there. With the fifty thousand families in California, the twenty-three thousand families in Arizona, the twenty thousand families Dr. Mead wants for his projects, and a number of other private projects that need people, and I can in a moment or two count up from one hundred fifty to two hundred thousand families needed for the irrigated sections of the West. The question is, where to get them.

Another thing that is wrong, in my opinion, and which is being corrected now by the Fact Finding Commission, is the lack of classification of lands. In a project of 100,000 acres, it doesn't follow that all of that is good. Some land is rough, some is level, some is good land, some is poor land, some is deep soil and some is hardpan, but this land is all assessed at one round price all the way through.

Dr. Mead discussed this matter of capital for the settler, and that is a very important matter. From our surveys, under the investigation that we make in our own activities, we find that fully seventy-five per cent. of the people we come in contact with have only capital to the extent of two thousand to twenty-five hundred dollars. The people who have more capital will not be attracted to these irrigation projects, they will not pioneer, because a man who has that amount of capital is looking for the finished or the going farm in some well defined community.

H. G. Clark, M. W. S. E.: I had hoped to hear from Dr. Mead as to the activity of the government in drainage matters, particularly in the Southern country.

I also thought perhaps he might say what led the Reclamation Department to decided that we would have a reclamation project started on some river in Wyoming, as compared with some drainage condition in Louisiana or Arkansas or some other place, which perhaps might afford at a lesser expense a considerably greater territory for farm projects of this kind.

Dr. Mead: I will say that the Reclamation Act under the Constitution is confined at the present to the arid domain. The original Act applied the proceeds of sale of the public lands in 17 states that were named to the development of those states. But Congress is considering the question that has been asked, as shown by the provision in the last appropriation act for money to investigate the development and reclamation of lands outside of the arid regions. But it is a new question as yet.

W. M. Randolph, M. W. S. E.: I would like to ask if the government builds power houses to utilize the power in connection with the reservoirs.

Dr. Mead: The development of power is comparatively recent, because in the early stages of the development there was no market for power. But provision is made for power development in the works now being built at Guernsey, on the Platte River, and on the Snake River at American Falls, and the power revenue from the Salt River Project is the largest

part of the revenue. It surpasses the revenue from the sale of water for irrigation purposes. And as the country fills up and opportunities to market power increase, there is no question but that that will be a larger and larger factor in determining the feasibility of future reclamation projects.

TECHNICAL PAPERS

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The Chicago Union Station

By Joshua D'Esposito,* M. W. S. E.

Presented October 12, 1925

The group of structures and improvements—buildings, tracks, viaducts, freight and mail handling installations, etc.,—generally known as the Chicago Union Station Project, is now practically completed and in operation. The extent of the changes wrought in this territory embraced by these facilities, the magnitude of the building operations involved, the values of the properties affected and the multiplicity of the interests involved, surround this undertaking with an importance to the engineering profession beyond the mere physical factors overcome in its accomplishment.

IT HAS been my good fortune to be connected with this enterprise from the very beginning of its activities and I may be pardoned for taking upon myself the privilege of outlining a short history of the development of the preliminary plans, culminating in the adoption of a scheme satisfactory to all interests concerned, and according to which the work was finally carried out.

The history of this improvement goes back practically to the beginning of the century; as a matter of fact, the inadequacy of the old Union Station manifested itself during World's Fair times in spite of additions and improvements of a permanent nature undertaken and carried out in preparation for that event. But other matters of equal if not greater importance kept intruding from time to time and compelled the considerations of the solution of the Chicago terminal problem. The most important factors of this character in the order of their importance would seem to be the following:

(a) The inadequacy of the freight terminals of the several railroads involved.

(b) The building of the Drainage Canal and the consequent widening of the Chicago River, causing the restriction of railroad facilities and of the amount of land available for development.

(c) The uncoordinated but nevertheless determinate effort of the City of Chicago to force a solution of the railroad terminal problem.

In order to understand the complexities of this problem, it is necessary to have a general knowledge of the situation as it existed before any work was done, say previous to 1900. At that time the Union Station proper occupied land approximately 135 by 1770 feet, immediately east of Canal Street from Van Buren Street to Madison Street. Upon this ground there existed the station building proper, two baggage buildings, a mail building, a number of tracks and trainshed. The track system was that of a through station type, with approaches from the north and from the south, but the station actually was operated as a double stub with trains over-running the center of the layout at both ends. The approach tracks both from the north and from the south were located in what had formerly been city streets, in one case West Water Street and in the other Stewart Avenue.

These streets had never been vacated, and at their intersection with several east and west streets contained several grade crossings at the very throat of the Station. East of the tracks proper were located the freight houses and team tracks of the Pennsylvania Lines, while flanking both approaches there were a number of freight houses and team tracks of other roads and several important industries, in

* Chief Engineer, Chicago Union Station Co.

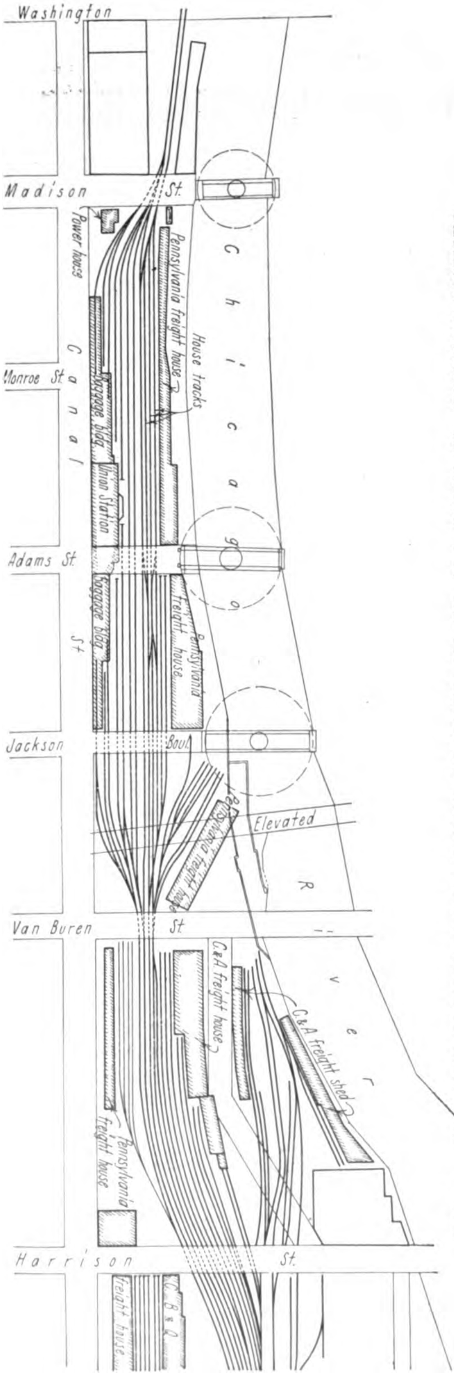


FIG. 1. THE OLD UNION STATION WAS HEMMED IN ON ALL SIDES BY FREIGHT HOUSES.

many cases with permanent and substantial buildings. In other words, the Station itself and the approach tracks to the Station were hemmed in, in such a way, as to render the question of expansion and rearrangement a complicated and costly undertaking, and it is but natural that several of the earlier studies contemplated developments on grounds outside of the then existing facilities, unencumbered by railroad structures and to a large extent free of expensive private facilities.

For several years there was this struggle going on in the minds of people charged with the responsibilty of making a decision on these improvements—whether or not an attempt should be made to unscramble the railroad ownership and rebuild upon the then existing railroad properties, or to go on new ground and build without interfering with the existing facilities. Eventually the advocates of the project involving the relocation of the station on ground free of railroad facilities lost out, and it was decided to locate the new station on the site occupied by the old one absorbing as many adjacent railroad facilities as required, replacing these by the purchase of additional land and the extension of freight facilities as the case required. Eventually it came to pass that more properties had to be purchased in carrying out this scheme than originally contemplated, so much so as to equal in extent the lands that would have been purchased on any of the schemes of the other types.

Whether or not a realization of this plan would have influenced the ultimate decision, it is now impossible to say, and for that matter it is an idle speculation, as in all likelihood changes in the requirements, expansion of facilities and other unforseen conditions would have had to be met in the case of any scheme mainly by reason of the fact that modern life moves swiftly, making demands from year to year impossible to foresee with any degree of accuracy. In the case of a railroad terminal requiring ten years or more for its construction, the difficulties are magnified by the fact that it is extremely difficult to make radical changes during the course of development of plans and during the period of actual construction, and as a result the completed improvement will contain a number of com-

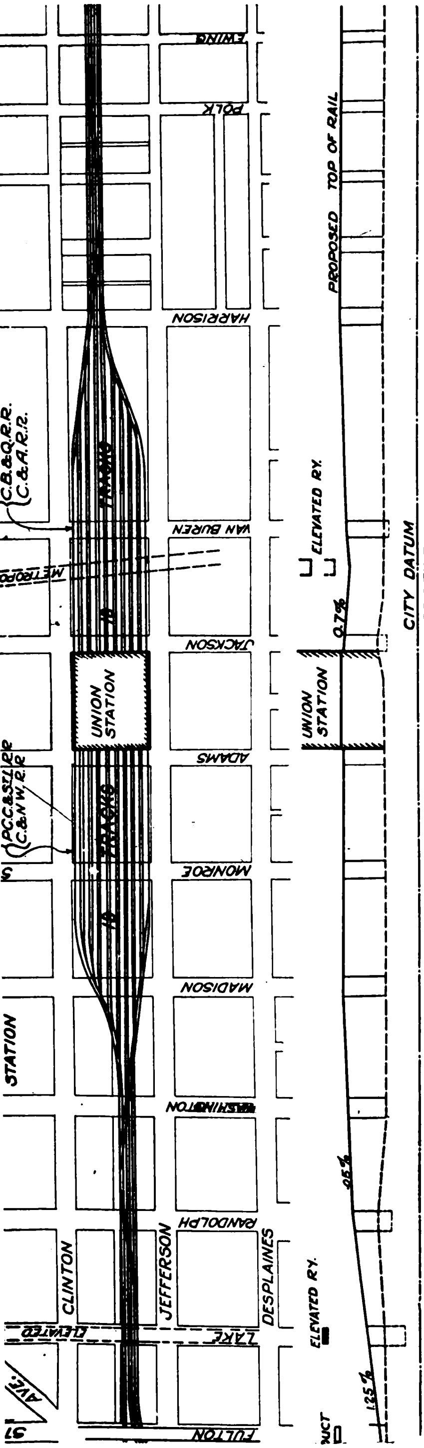


FIG. 2. ONE OF THE FIRST PLANS PROPOSED.

promises more or less satisfactory, but not at all what they would have been if their needs had been foreseen at the inception of the project.

Many Plans Considered

The schemes which will be considered in this paper are only a few of the many developed in the period from 1900 to 1912, and they were chosen on account of typifying general conceptions. The selected studies are presented under two general types, the first contemplating largely the development of facilities on ground free of railroad improvements; the second contemplating the use of ground occupied by railroad facilities, expanded by the acquisition of adjacent land.

In the first group we have a scheme prepared in November, 1905, proposing a double stub station with the building located between Jackson and Adams Streets and Clinton and Jefferson Streets. (See Fig. 2.) In this, the station proper would have been one block west of the present station, the tracks being located above the street level and the approaches worked out on a new right-of-way at both ends of the station. This scheme was given serious consideration, not only at that time but from time to time for several years after, the intention being that the north end of the station could accommodate both the Chicago, Milwaukee & St. Paul Railway and the Chicago & Northwestern Railroad, and I may say that in all probabilities this quality of the plan was one of its major defects.

Another interesting project of this general type was a plan prepared in October, 1906, which placed the station in the block between Madison and Monroe Streets and Jefferson and Desplaines Streets, the south approach tracks coming over the present right-of-way and curving west into the station, while the north approach tracks formed a group parallel to and one block west, but in about the same location corresponding to the present Chicago & Northwestern Station layout. This is shown in Fig. 3. In this case the tracks from the south would have been at a level below the street, while the tracks from the north would have been at a level above the street. The station floor and concourse were intended to be placed practically at the street level, necessitating stairways down to the low tracks and

stairways up to the high tracks. This arrangement, in the light of our present day knowledge of terminal development, has so many drawbacks as to render it almost unworkable from every standpoint. At any rate I do not find that very serious consideration was given to it at any time, and it is shown here to illustrate how carefully all matters were considered having any bearing on the problem.

A third plan, shown in Fig. 4, using properties outside of railroad ownership was prepared in 1906 and this forms a very interesting study even at the present time. Under this scheme the station building was located between Monroe and Adams Streets, Canal and Clinton Streets, that is in the same east and west block as the present station, but one block north. The approach tracks would have been left in their old location and the station tracks would have been run as far west as Desplaines Street, giving a stub station with the station building proper located above the tracks as in the case of a through station. This scheme was given serious consideration and quite careful estimates of cost were made, but the inadequacy of the track layout and the fact that the station could not be operated without electrifying the railroads rendered this solution unworkable.

As against the solutions based on the possibility of building the station on new lands, a large number of studies were prepared contemplating the intensified use of railroad properties added to and expanded by the purchase of adjacent land. Looking at the matter in retrospect it would seem now that this conception was at all times the favored one, and this would seem to be but an expression of the human tendency which always wants to remain on beaten paths and to adhere to settled and tried conditions. At any rate, whatever the cause I find that many more studies were made involving the use of properties in the possession of railroads than were made of the type using properties in new locations, and it has been somewhat difficult to pick out typical studies out of the large number at my disposal. By reason of their embodying some striking features, the following have finally been selected:—

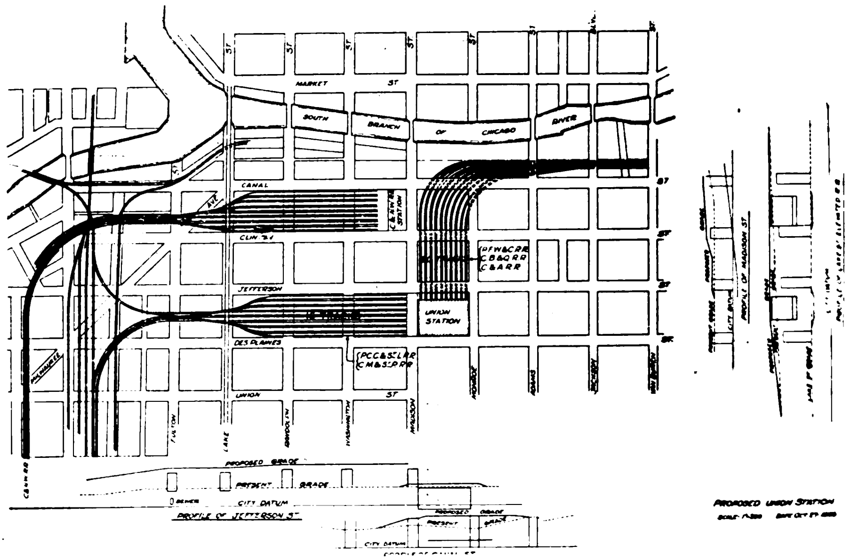


FIG. 3. A TWO-LEVEL STATION PROPOSED ON WEST MADISON STREET.

A plan was prepared in 1904, showing a station of the through type with the station building located between Monroe and Adams Streets, the tracks occupying all the space between Canal Street and the River, the evident intention of the originator of the scheme being the desire to leave undisturbed the freight properties of the Chicago & Alton and the Burlington Road south of Van Buren Street. The limited scope of the solution quickly

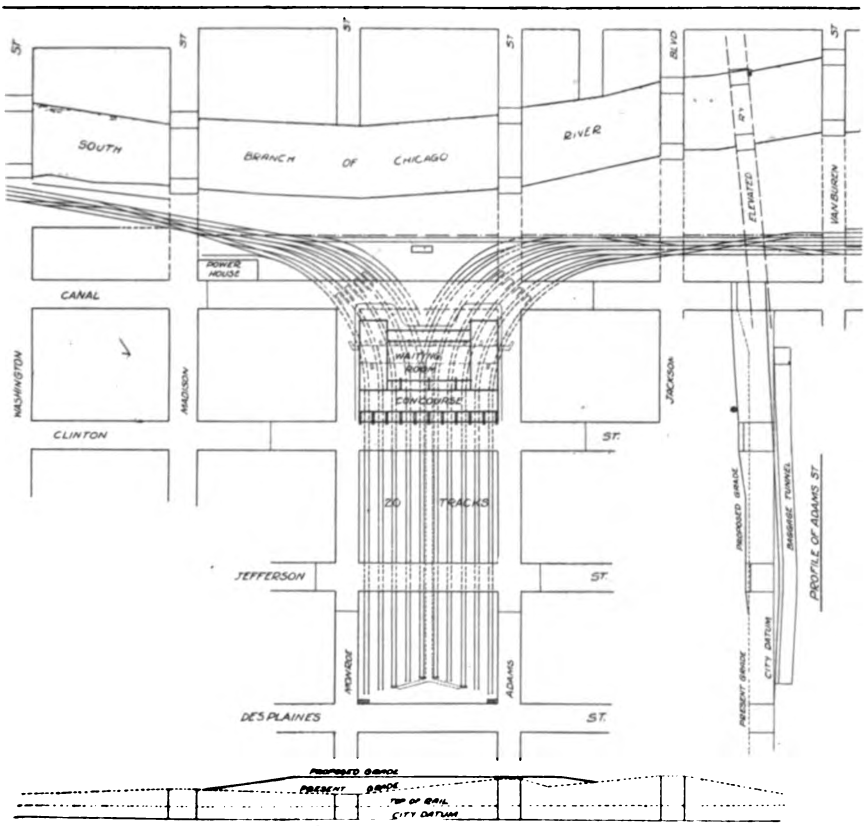


FIG. 4. PLAN WITH TRACKS BELOW STATION REQUIRING ELECTRIFICATION.

convinces one of its inadequacy and it must have been the consciousness of that limitation which prompted the development of another plan in August of the same year, shown in Fig. 5, wherein the station building is shifted about 1000 feet south and is placed between Van Buren and Harrison Streets, no attempt being made to preserve the integrity of the freight layout of either the Alton or the Burlington roads.

During the following year the project seemed to have been given more serious consideration than ever before, and studies were made which showed an originality of conception not found in previous studies. A plan prepared about that time anticipated some of the conceptions of terminal problems as outlined today by interests other than the roads in the Union Station group.

In this plan the River is straightened from Taylor Street to 16th Street, somewhat farther west than the channel considered at present. The station is boldly located east of the river fronting on Van Buren Street with a corresponding rearrangement of railroad ownership not unlike some of the plans which have ben considered lately for a station in approximately the same location. This is shown in Fig. 6.

An even more interesting solution was proposed in 1905 and given very serious consideration by the Pennsylvania management. This solution was worked out by B. V. Sommerville, now Assistant Chief Engineer of the Pennsylvania Railroad. Mr. Somerville's solution was in no manner a half-way measure, as shown in Fig. 7. He foresaw at that time that all the properties east of Canal Street

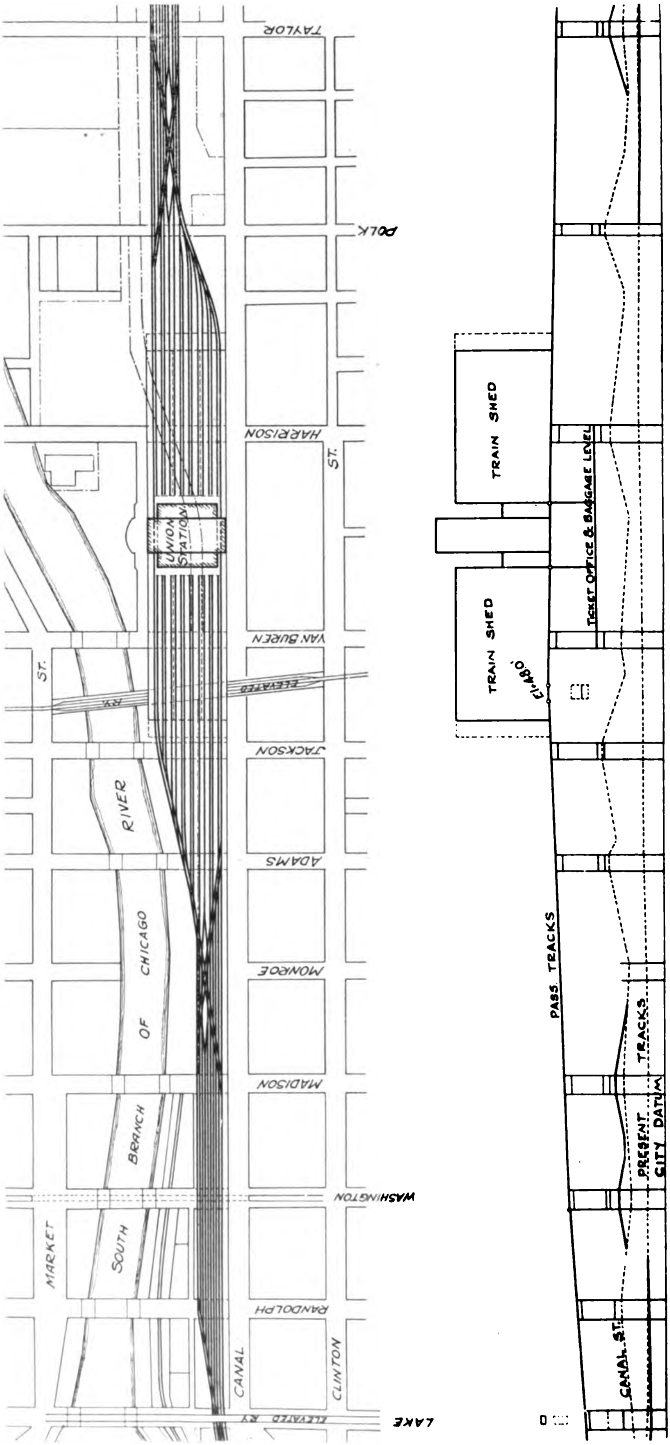


FIG. 5. PLAN OF A THROUGH TYPE OF STATION SOUTH OF VAN BUREN STREET.

from 16th Street to Lake Street would eventually have to be acquired by the railroads and his plan is based on such assumption. The station arrangement as developed in this study is that of a double stub type with the tracks above the street level, the station building being located between Jackson Boulevard and Adams Street, with facilities both at street level and at track level. In order to eliminate or reduce the necessity of purchasing additional land for the Pennsylvania Freight Terminal, it was proposed that the freight houses and team yard be located below the street level in the same area occupied by the passenger station facilities. In other words the ground would have been utilized at three levels, the uppermost level for passenger tracks, the intermediate or street level for baggage, mail and express operations, and the lowest level for the handling of the freight. It was also proposed to erect an office building in connection with the station building proper, running the Metropolitan Elevated railroad right through the building so that passengers could be easily interchanged from the station to the Elevated System.

Another feature of this plan, which is not illustrated in the print shown herewith, is the proposal for a joint coach yard for the Pennsylvania and Burlington railroads south of 12th Street, a suggestion that has many good qualities and which was given serious consideration in connection with the development of the present plan.

A scheme which had to be given some consideration somewhat later in the process of development was that involving the location of the station at 12th Street. A solution of the Chicago terminal problem relocating all the passenger terminals south of and facing 12th Street, now Roosevelt Road, was developed and advocated by Mr. Delano, several years previous to the time under consideration, but the solution, either in whole or in part, never found favor with the owners of the railroads in the Chicago Union Station project.

They were confronted with the compelling necessity of adjusting their own facilities, utterly inadequate and unable to meet existing and pressing requirements, and very properly they solved their problem to the best of their knowledge and ability without involving factors beyond

FIG. 6. A PROPOSAL TO RELOCATE THE CHICAGO RIVER TO PROVIDE FOR A UNION STATION.

their control. The scheme which was finally adopted was first outlined in 1906, as shown in Fig. 8, but at that time it was not contemplated to come west of Canal Street with any station facilities. In the original scheme the track layout was approximately that which was carried out, but the station building was located in the block between the river and Canal Street, Adams Street and Jackson Boulevard. The floor of the station was at the street level, stairways leading from the street level to the platforms both north and south of the station.

This solution was originally proposed by Thos. Rodd, at that time Chief Engineer of the Pennsylvania Lines West of Pittsburgh, and found favor from the very beginning. In this scheme the additional land needed for the expansion of the Union Station project was mainly in the possession of the Pennsylvania Lines and could therefore be acquired by the Station Company without much difficulty. There was, however, the necessity of dealing with the Alton road and to some extent with the Burlington for some portion of their freight facilities south of Van Buren Street, but it was assumed that negotiations involving the acquisition of these lands could be carried on expeditiously and satisfactorily. As matters turned out, this was not entirely the case, as the Alton's negotiations extended over a period of years and were not concluded until some time after the work of construction had actually started.

In the meantime, anticipating the needs of the situation by several years, the Pennsylvania Lines acquired an extensive and costly piece of ground two blocks west of the station proper for the purpose of rebuilding its freight terminals, and likewise the Burlington road acquired the Crane Co.'s plant, as well as all of the private properties east of Canal Street both north and south of 12th Street. Later it was found impossible to secure the necessary legislation permitting the construction of the freight houses for the Pennsylvania Lines where it had originally been contemplated and as a result, this facility had to be relocated immediately west of the Chicago River from Polk Street to 12th Street, so that eventually all the land between Canal Street and the river, Kinzie Street and 12th Street, with the exception of that occupied by Butler Bros., came under railroad ownership.

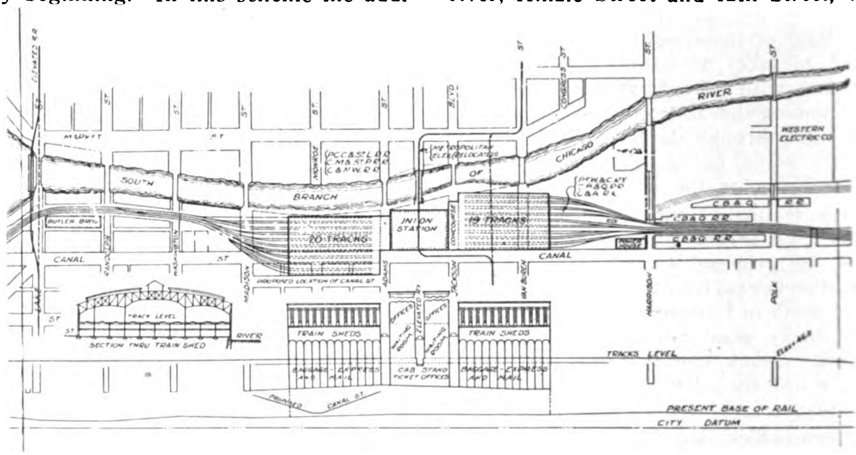


FIG. 7. THREE-LEVEL STATION AND OFFICE BUILDING.

The plan of the station proper as tentatively agreed upon at about this time did not contemplate coming west of Canal Street with any facilities and tentative studies of the station, were begun with all its facilities and appurtenances located above the tracks in the block between Adams Street, Jackson Boulevard, the Chicago River and Canal Street. The restriction imposed by the limitation of this area soon became manifest and in 1911 the decision was made to increase the proposed facilities by the addition of a block west of Canal Street, locating the main station building on this block and connecting it with the tracks by passage-

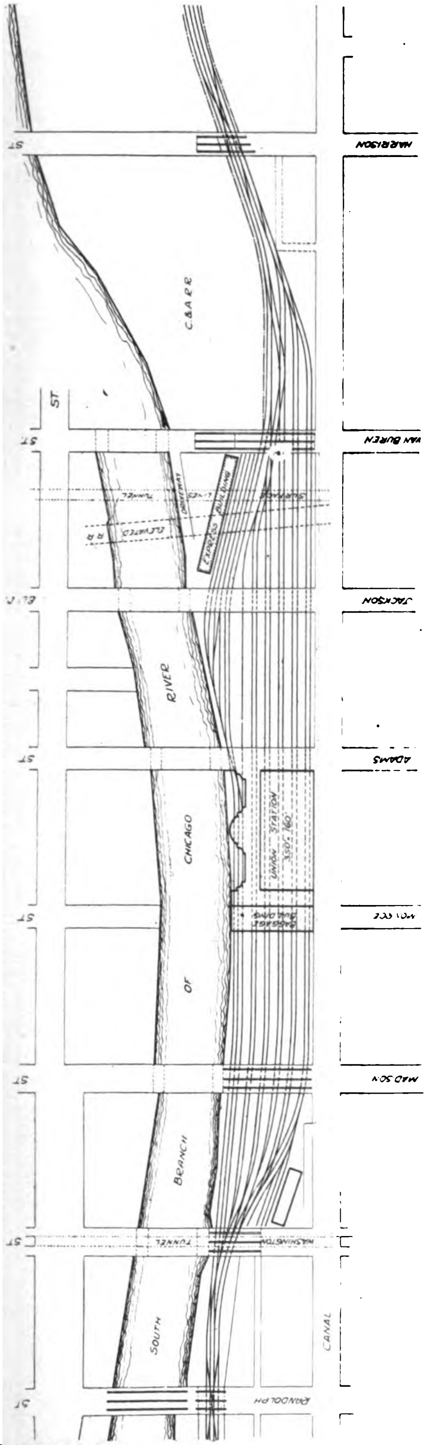


FIG. 8. THIS PLAN PROPOSED IN 1906 WAS FINALLY ADOPTED WITH MODIFICATIONS.

way under Canal Street, as shown in Figs. 9A and 9B.

This decision was reached in the face of many serious disadvantages inherent to the situation. In the first place the station building being located west of the tracks would be away from the loop district which was then considered the source of railroad passenger traffic; in the second place, Canal Street separating the station building from the tracks proper would necessitate long passageways, and in the third place, the difference in levels between the street at the west end of the Station, Canal Street and the tracks would make the arrangement of floors and facilities a formidable problem. In spite of these evident drawbacks, the decision was adhered to and the step taken and it is interesting to note that some of the conceptions outlined in the very first sketch made when this decision was reached have been carried out in the ultimate layout. I happen to know, for instance, that the arrangement of cab driveways and cab stands as now installed was indicated on a pencil sketch made on an ordinary sheet of paper by Thos. Rodd in his office in Pittsburgh several days before an agreement was reached on the purchase of this block.

It would be a physical impossibility and would require more time than is available to place before you even a small number of the studies of the plans of the building considered over a period of three years and in some cases developed to the extent of making possible a careful analysis of the various functions, and the estimated cost of building as a whole, but in general an effort will be made to outline the outstanding characteristics of the important variations leading to the scheme which was finally adopted.

These variations are in the main the following:

(a) A station building west of Canal Street with the main floor at the level of Canal Street, a narrow Concourse east of Canal Street connected to the main building by means of stairways or ramps, or both.

(b) A station building west of Canal Street, the floor being at an intermediate level between Canal Street and the Concourse level with ramps from the street to the level of the main building and

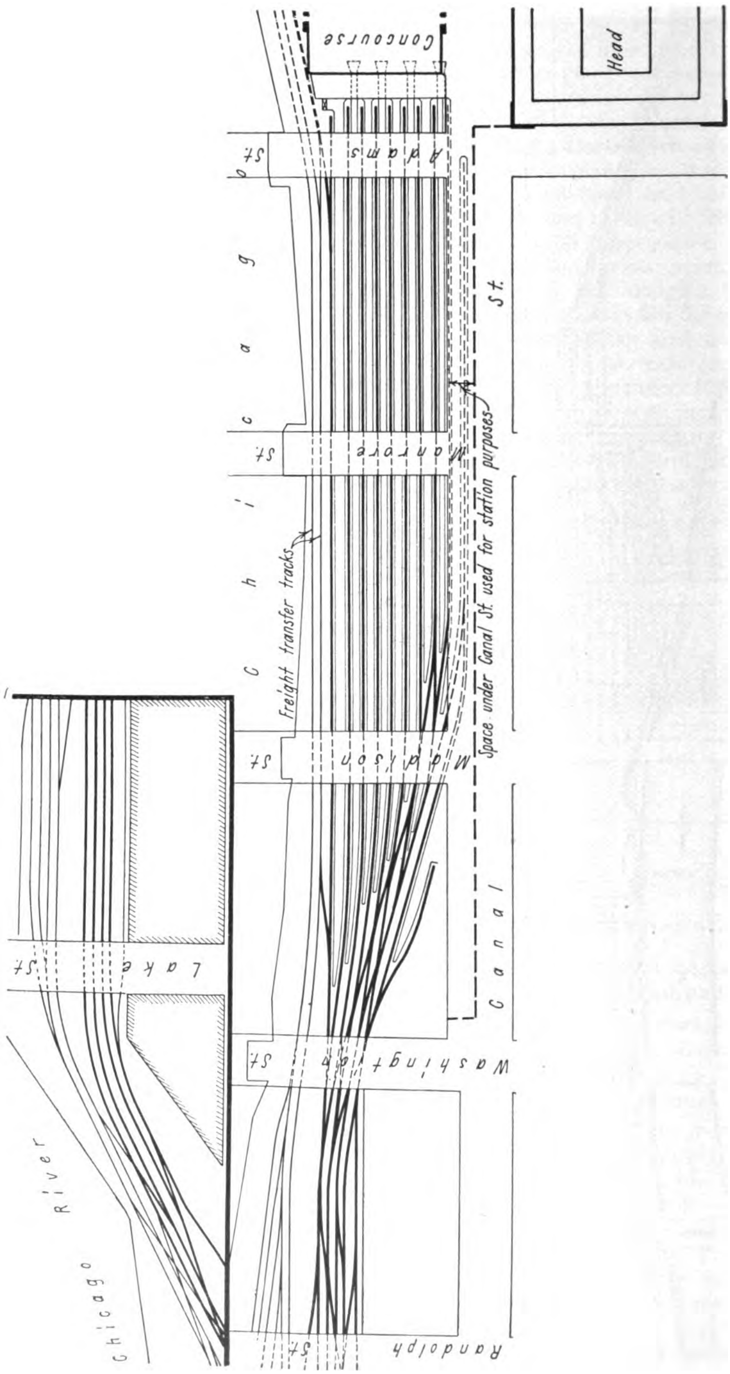


FIG. 2A. NORTH HALF OF THE NEW TERMINAL (THE EXTENSION OF THE NORTH END IS SHOWN IN THE UPPER LEFT CORNER.)

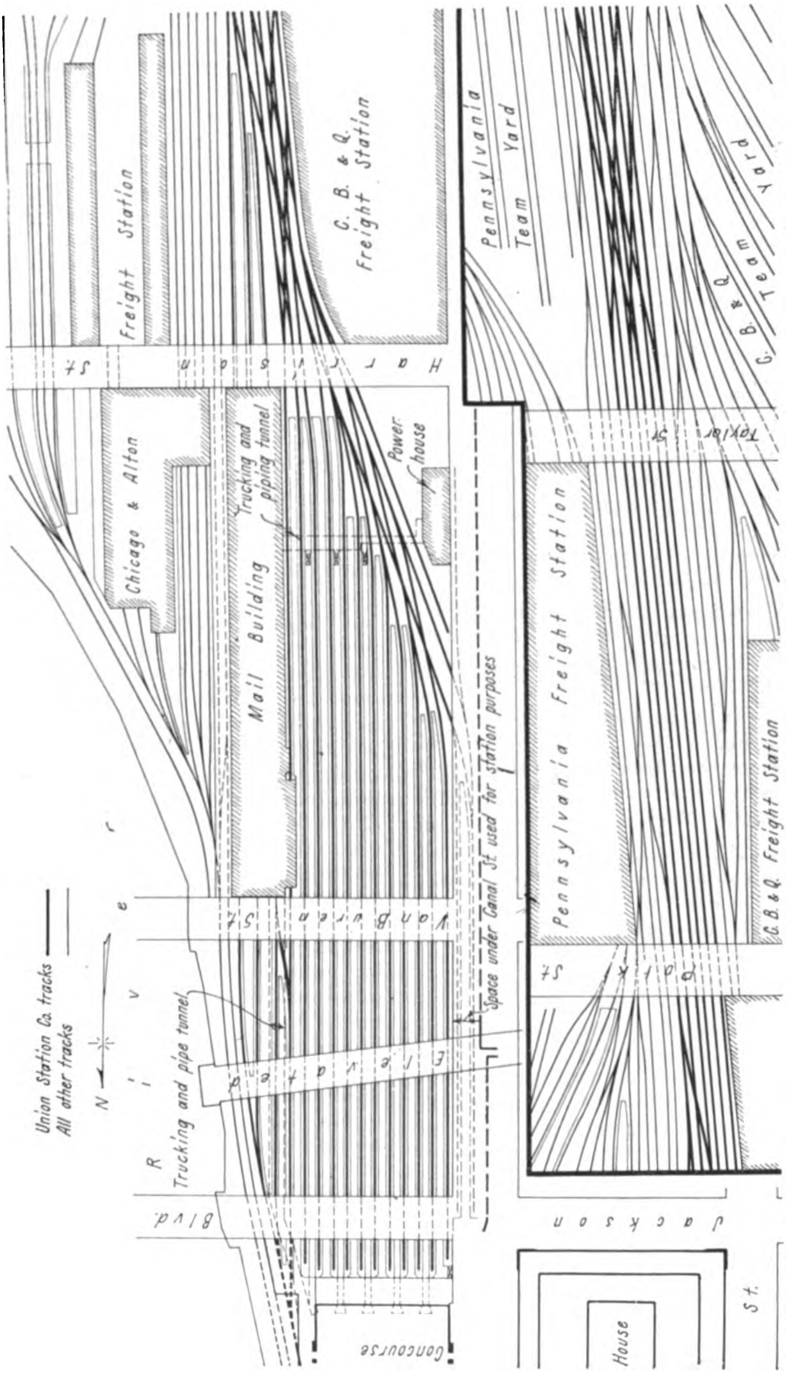


FIG. 9B. SOUTH HALF OF THE NEW TERMINAL (THE EXTENSION OF THE SOUTH END IS SHOWN AT THE LOWER RIGHT CORNER.)

ramps from the floor of the main building to the Concourse level, the baggage being received and delivered on Clinton Street, or at the rear of the station.

(c) A main station building west of Canal Street with the floor at the Concourse level and a balcony running all around the waiting room at the level of Canal Street for the accommodation of restaurants, rest rooms and other facilities.

(d) A main building west of Canal Street with the axis of the main waiting room running east and west, making the main waiting room an extension of the Concourse.

(e) A main building west of Canal Street in which the main waiting room was placed almost immediately west of the street and at the west end of said room there being located a group of facilities, such as restaurants, rest rooms and everything else that goes into the service of a station.

(f) A combined station and hotel project arranged so that the waiting room would be on the east half of the block and the hotel on the west half.

(g) A main building west of Canal Street having a large central dome in the center of the block with radial ramps and stairways approaching from the four corners of the block.

All the above major types would be developed to the extent of locating minor facilities, arranging the space for railroad service, developing a baggage handling system, etc., but by a process of elimination some characteristics assumed their proper importance and became either an accepted factor or were discarded from further consideration. For example, the idea of separating the station floor in two levels was very quickly eliminated; the arrangement for handling of baggage at the rear of the station along Clinton Street became more difficult to work out and less and less attractive as time went on. The conception of a passageway between the Concourse and the Station proper west of Canal Street very quickly gave way to that of a broad, ample connection covering the full width of the block; the arrangement with the general waiting room on the east and west line very quickly became unmanageable so that eventually and very simply we came down to a scheme of a one level station having a main waiting room west of Canal Street adequately connected with the section of the station east of Canal Street, and then the problem became one of arranging the various facilities within this space and also finding a way of handling baggage to and from trains to trucks and cabs. This element of the problem hung fire for a long time until someone originated the scheme of a return of the cab drives back to Clinton Street, then returning under the waiting room to Canal Street, delivering and receiving the baggage at baggage room level, thereby eliminating the necessity of elevators for all that service.

In the first arrangement the baggage room was placed directly underneath the waiting room floor and tunnels were to be built from the tracks, passing under Canal Street to a baggage room west of it. Later on when we began to develop the various facilities required for the operation of the station it became evident that there would not be sufficient space under the floor of the main waiting room for a baggage room as well as the innumerable other facilities, and the suggestion was made to excavate under the Concourse and extend the drive in the center of the building directly to the baggage room close to the end of the trains, leaving the entire basement free for machinery space, storage, etc. This suggestion at once made possible the broad and free development of the station building proper in a manner that for the first time met the requirements of the situation. As it is now, the baggage is delivered by motor trucks almost to the train itself and by the happy arrangement of separate baggage platforms, ramped or inclined directly into the baggage room we believe that we have the best arrangement for this kind of service in any of the existing large terminals.

In a building of whatever nature intended to answer a multitude of requirements and to accommodate a very large number of people, with many parts performing dissimilar and sometimes unrelated functions, the problem of interior arrangement of facilities assumes an im-

portance beyond that of architectural or aesthetic requirements. In the case of our building the problem was further complicated by several unavoidable conditions as has been related in the foregoing pages.

A study of Fig. 10, showing the location of the important facilities in their relation to the axial lines of the layout, illustrates the fundamental principle underlying the selection of their location. It will be noted that the center of the layout is approximately under Canal Street in the space between the concourse and the main waiting room and that the most active functions of the station have been grouped as closely as possible to this center, it being assumed that this point, surrounded by the major entrances, would be the nerve center of the station. These major entrances and exits were assumed to be the two cab stands, which conclusion is based on the belief that the approach to the station by our patrons will be more and more by means of motor vehicles, and the actual operation of the station seems to justify this assumption.

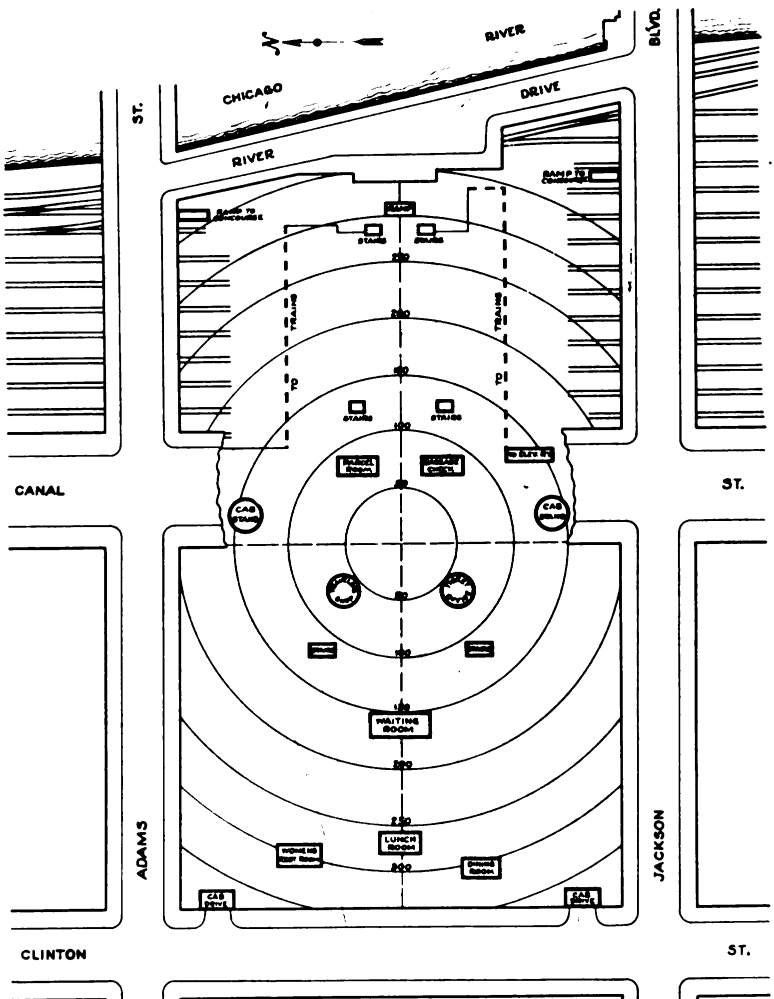


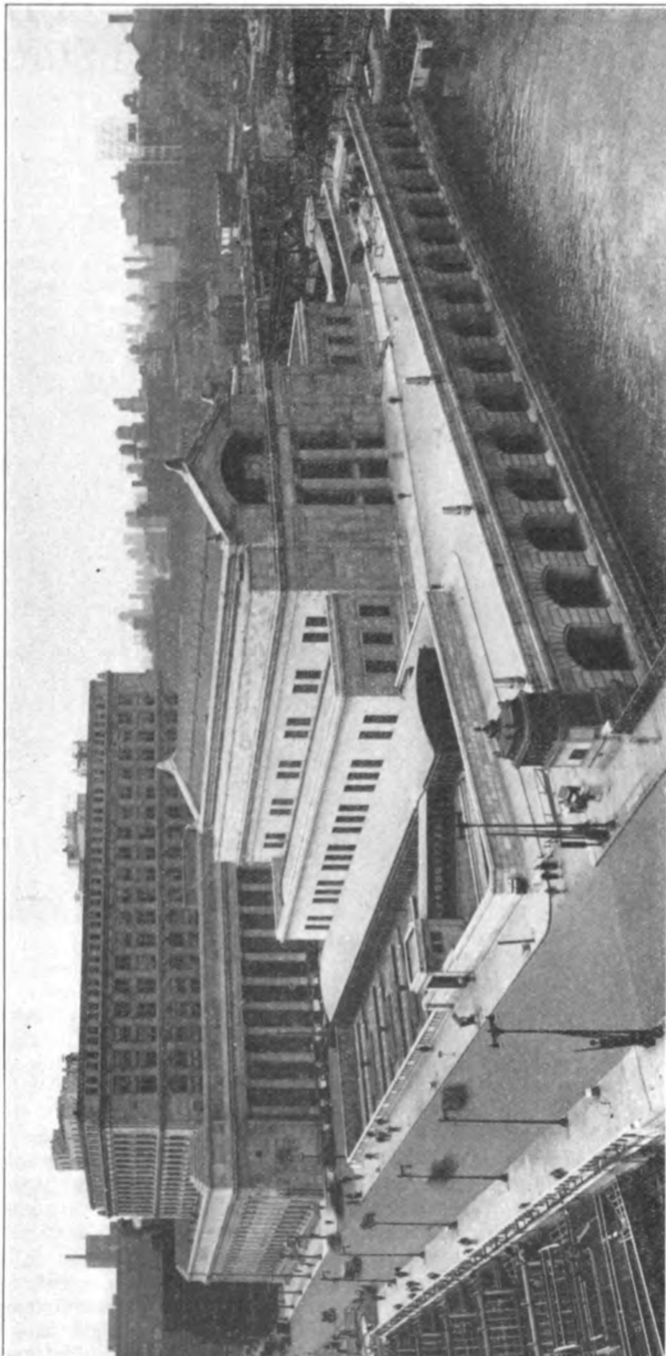
FIG. 10. THIS DIAGRAM SHOWS THE DISTANCES OF FACILITIES FROM THE EXACT CENTER OF THE STATION.

In accordance with this basic thought, the major requirements of the railroad terminal would seem to be — first, that of supplying the passenger with the necessary transportation; second, with a visible, adequate and convenient service for checking baggage or parcels; third, with a place where he can quickly supply himself with whatever necessities he may need for his trip, such as wearing apparel, books, merchandise, etc., and then by the shortest possible route leading to the train gates and to trains. Rest rooms, general shops, restaurants, etc., can be placed at a distance from the center of activities, as the user of these facilities normally should have time at his disposal and in our layout they have been located at the rear end of the main building. Architectural requirements were in a measure subordinated to practical ones, the first thought being that the station should be a good working layout as well as a beautiful building.

To what extent we accomplished what we set out to do, namely the development of a convenient, economical, easily operated and attractive building, is a question which time will tell and for that matter we who had something to do with the creation of this improvement would naturally be the poorest judges of the success of our efforts.

It would be presumptuous on my part to attempt to apportion the proper share of credit due to all those who contributed much or little toward the creation of this improvement, but I may be permitted to record here the names of those who after contributing their share either had to retire on account of age or were called by death before the completion of the work. Of the former, J. J. Turner, formerly Vice President of the Pennsylvania Lines and first President of the Chicago Union Station Company, directed all the activities of the station from its inception until 1922. Thos. Rodd, first Chief Engineer, under whose charge most of the preliminary studies were prepared, retired in 1919. Samuel Rea, former President of the Pennsylvania Railroad System, was President of the Chicago Union Station Company from 1922 to the time of his retirement in 1925. Of the latter, Darius Miller, late President of the Chicago, Burlington & Quincy Railroad Co., was most prominently connected with the activities resulting in the legislation and financing of the project in 1914 and 1915. The late A. J. Earling was President of the Chicago, Milwaukee & St. Paul Railway Co., when the ordinance was passed. E. A. Howard, Vice President of the Chicago, Burlington & Quincy Railroad Co. was a very active and energetic chairman of the Executive Committee of the Union Station Company, right up to his death in 1921. E. D. Sewall, Vice President of the Chicago, Milwaukee & St. Paul Railway Co., was a Vice President and member of the Executive Committee of the Chicago Union Station Company from 1914 to the time of his death in 1923. A. S. Schoyer and J. G. Rodgers, Vice Presidents of the Pennsylvania Railroad, were Vice Presidents of the Chicago Union Station Company for several years.

As far as those who have actually carried out the work, I wish to state that the Station Company has been well served by a devoted and conscientious staff of engineers, most of whom have stayed with it during the entire period of construction, and it is to their individual efforts, loyally and conscientiously given over a period of years, that the credit is due for the successful completion of a very difficult and trying undertaking.



VIEW OF THE COMPLETED CONCOURSE AND HEADHOUSE FROM THE SOUTHEAST.

Construction Program and Method of Handling Traffic on the Chicago Union Station

By E. E. Stetson,* M. W. S. E.

Presented September 28, 1925

The schedule of construction operation is frequently just as important as the design and sometimes more difficult of solution. Here is an example of where the scheduling of actual building operations was made more difficult because it was necessary to maintain the normal flow of traffic in a region already overcrowded.—Editor.

ONE of the most important, as well as troublesome, problems encountered in the construction of the new Union Station was the matter of handling the railway traffic. Some idea of the volume of this traffic may be obtained from the follow'ng statistics of business handled at the station:

Average number of schedule passenger trains per day	265
Average number of passengers per day	50,000
Average number of mail cars per day	150
Average number of pieces of baggage per day	5,000
Average number of pieces of express per day	3,200

The above regular business, together with the innumerable switching movements, freight transfers, special and extra-section trains, had to be operated constantly without delay during the construction work.

In this project, all the facil'ties with the exception of the Headhouse Building (or station proper), had to be constructed in a very restricted space already occupied and highly congested with railway traffic. Furthermore, in the new improvement the grade of the tracks and the clearance lines of the new viaducts were lowered from 4 to 6 feet. This condition made it necessary to lower the tracks before constructing the new viaducts in order to provide the necessary clearance for the operation of trains. Because of this feature, and the fact that the piers of the new viaducts interfered with the existing approach tracks, it was essential that the viaduct and track construction be carried out in proper sequence. The new track layout had to be built in stages of one or two tracks at a time; each track or group of tracks having to be completed and placed in service before work could be started on the next unit.

Under these conditions, the construction operations had to be carefully coordinated and therfore it was deemed advisable before starting any construction work to develop a complete program of operations. Plans were prepared illustrating the various stages to be followed in the execution of the work and submitted to the operating officials for approval. Briefly, the plan of procedure as finally adopted was as follows: First—To construct the new freight house and Butler Building. Remove the old buildings located on the site of the work. Second—to reconstruct sewers and other necessary utilities and raise the grade of Canal Street. Third—Build the new viaducts and track layout simultaneously with the construction of the new station building, work on the viaducts and tracks to commence at both the South and North ends of the improvement and proceed to the center. The old station at Adams Street and also the viaduct at this street were not to be disturbed until after the new station was completed and in operation. The construction of the new track layout was to be started on the west (or Canal Street) side of the right-of-way after moving the existing tracks over to the east side temporarily, then shifting traffic over to the permanent tracks as they were completed, and finally constructing the east portion of the layout; the object being to avoid lowering the tracks under traffic as much as possible.

This program has been followed in a general way throughout the construction operations; although some changes had to be made to meet delays and conditions that developed during progress of the work.

* Principal Assistant Engr. Const., Chicago Union Station Co.

The first actual construction work in connection with the new station improvement was the building of the new viaduct at Lake Street and the new freight terminal at Polk Street, by the Pennsylvania Railroad Company, which was commenced early in 1915. In the latter part of 1915, the Chicago Union Station Company completed its organization and started work on the program of construction. The first work to be undertaken was the reconstruction of sewers; the construction of the new Monroe Street bridge and the new dock wall along the river; also the raising of the grade of Canal Street; together with the relocation of all public utilities in the streets affected. This work could be completed without interfering with railroad traffic. From the middle of 1916 to 1918, practically no progress was made on the construction program on account of labor strikes and the entrance of the United States Government into the Great War.

Early in 1919 the construction work was actively resumed. The erection of the new Butler Brothers Building at Randolph Street, the Chicago and Alton South Freight House, south of Harrison Street and the Headhouse foundations were started. At the same time, work was commenced on the Taylor, Polk and Harrison Street viaducts. The construction of the new Chicago and Alton South Freight House was a most important item, as their old freight house facilities (located between Harrison and Van Buren Streets) was occupying Union Station Company property that had to be vacated at an early date in order to carry out the program. With a view to expediting this work, a temporary team track yard, with a capacity of 50 cars, was built for the Chicago and Alton Railroad on vacant property of the Pennsylvania Railroad Company between Taylor and 12th Streets. Later, this yard was used to very good advantage for the handling of structural steel and track materials.

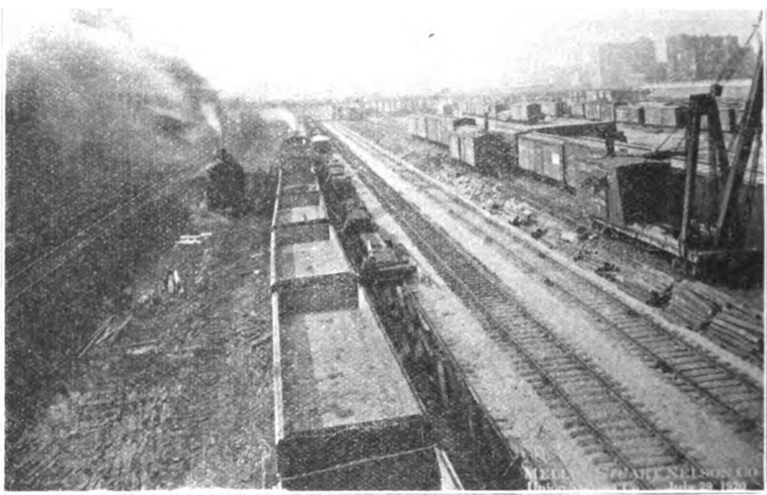
THE APPROACH TRACKS SOUTH OF TWELFTH STREET WERE THE FIRST TRACKS LAID.

In June, 1919, all operations were again temporarily suspended for a period of three months, due to a labor strike and lockout. Work was finally resumed again in the fall of 1919 but was severely handicapped by inefficient labor, a railroad car shortage, and the exceptionally long and severe winter of 1919-1920. Despite these difficulties, however, good progress was

made, especially on the Taylor Street viaduct which was completed in February, 1920. This street was closed to all traffic during construction which greatly facilitated the work. It was necessary, however, to lower the main tracks and the C. B. & Q. freight yard tracks about 4 feet to keep railroad traffic in operation.

At both Polk and Harrison Streets the street traffic, including Surface Line cars, was kept in operation practically throughout the period of construction. In the case of Polk Street, which was widened 20 feet, this objective was rather easily accomplished by building the south half of the new viaduct before disturbing the old structure. This plan, however, was a very slow process as it necessitated building two viaducts instead of one. The situation at Harrison Street was more complicated. In order to build half of the new viaduct at this street, it was necessary to move the three truss spans laterally 20 feet north, and also build approximately 276 lineal feet of trestle from the river bridge to connect up with the east end of these spans. The old viaduct spans were also raised a sufficient amount to allow the steel for the new viaduct to be erected under the trusses. The west leaf of the river bridge also had to be raised several feet as well as the intersection at Canal Street.

After the foundations had been completed, the old spans were successfully moved in during the latter part of 1919, and work commenced on building the south portion of the new viaduct of sufficient width to include both of the Surface Lines tracks. Traffic was then diverted into this completed portion of the new viaduct; the temporary structure removed, and the remaining portion of the viaduct completed.



EXCAVATING FOR PERMANENT APPROACH TRACKS, WHICH WERE AT A LOW ELEVATION.

This viaduct was finished by the end of 1920, to the great relief of all concerned. It was, by far, the most difficult viaduct to construct in the entire project on account of traffic conditions of both street and railroad. All of the Chicago & Alton freight house tracks, as well as the main tracks, had to be lowered in order to obtain sufficient headroom under the new viaduct. This street also supported numerous public utilities which had to be relocated and rebuilt across the track and kept in service, which further complicated the situation. As a result of the

experience gained by the construction of the Harrison and Polk Street viaducts, the program of building the remaining viaducts was revised, namely, to close the street entirely and not attempt to maintain traffic during construction.

The first track work to be started was the construction of the south approach tracks between Harrison and Taylor Streets. Preliminary to this work, it was necessary to construct a new telegraph duct line, remove the existing pole line, and then move the old main tracks to work. The removal of the excavation from the front of the retaining wall along the west side of Canal Street caused a squeezing movement to take place in the soft clay sub-grade and the wall, together with the entire Canal Street over to the east building line and including the west curb wall, started sliding into the cut. This sliding was stopped by placing temporary timber braces in front of the wall and rushing the construction of the concrete track slab. The maximum movement of the wall was four inches and the

FIVE STATION TRACKS WERE CONSTRUCTED ALONG CANAL STREET. TWO PERMANENT TRACKS AT RIGHT CARRIED TRAFFIC TO THE OLD STATION.

the extreme east side of the right-of-way. The grading and construction of the new tracks was started in the fall of 1919, and finished one year later. This work was delayed by the severe winter as the concrete track slab foundation could not be laid until the frost was out of the ground in the Spring.

The next step was the construction of the five station tracks along Canal Street between Harrison and Van Buren Streets. These tracks were located west of the old main tracks and could be built without interfering with traffic. A rather serious situation, however, developed during this East sidewalk of Canal Street pulled away from the buildings a distance of about two inches. Further trouble of this kind was avoided by having the concrete track slab construction follow the excavation and keep close behind the steam shovel.

The Chicago & Alton freight house south of Harrison Street having now been completed, the next step in the program was the construction of the new Mail Terminal Building between Harrison and Van Buren Street and the portion of the Station tracks east of the mains together with the trucking tunnel connecting the Mail Building with the Power House. At

the same time, work was started on the Van Buren Street viaduct and Canal Street viaduct between Van Buren and Jackson Boulevard.

The above work all progressed without disturbing the main tracks or the interlocking plant at Van Buren Street. In order to accomplish this, however, it was necessary to leave out the two center spans of the Van Buren Street viaduct and make a temporary connection with the old viaduct span which was about two feet higher than the new viaduct. A street was barricaded and, in addition to the police, the fire department was present and even an ambulance. The trouble was quickly located. A section of the wooden sidewalk had become loose and had been lifted about a foot by the blast of locomotives passing underneath. The police had observed this displaced section of sidewalk and concluded that the bridge was breaking in half, and that part of it had already settled a foot.

The traffic congestion in Canal Street opposite the old station was now becom-

CENTER SPANS OF VAN BUREN STREET VIADUCT UNDER CONSTRUCTION. OLD METROPOLITAN STRUCTURE IN THE BACKGROUND.

rather amusing incident occurred in connection with this viaduct. One night, soon after traffic commenced operating over the new viaduct with this temporary span, I received a telephone communication from the Station Master that, according to the police, the old span had collapsed and all traffic discontinued over the bridge and that it was not safe to operate trains underneath. I hurried to the site, fully expectant to find serious trouble, as the floor system of the old span was in bad shape and the masonry abutments had been weakened in building the new foundation. Upon reaching the scene, I found great excitement. The

ing a serious matter. In order to relieve this condition, and in anticipation of the necessity of closing Canal Street in the near future, it was decided to build a temporary cab stand on the vacant property on Adams Street between Canal and Clinton Streets; this cab stand to be connected with the concourse of the station by a tunnel under Canal Street. This facility was constructed during 1921 and, in addition to eliminating the congestion in Canal Street, it was a splendid convenience to the station patrons. Upon the completion of the Van Buren and Canal Street viaducts, the westerly five station tracks were extended to the vicin-

ity of Jackson Blvd. Since these tracks were not very accessible to the old depot at Adams Street, it was decided to build a temporary annex station under the Canal Street viaduct at the track level with entrances and exits by stairways from Canal Street on both sides of Jackson Blvd. This facility together with the five new station tracks was placed in service in the spring of 1922. Temporary platforms with wooden umbrella canopies were constructed to serve the permanent tracks. This temporary station was of considerable assistance in handling the railroad passengers during the entire construction period and a splendid convenience for the suburban passengers of the railroads using the south portion of the station.

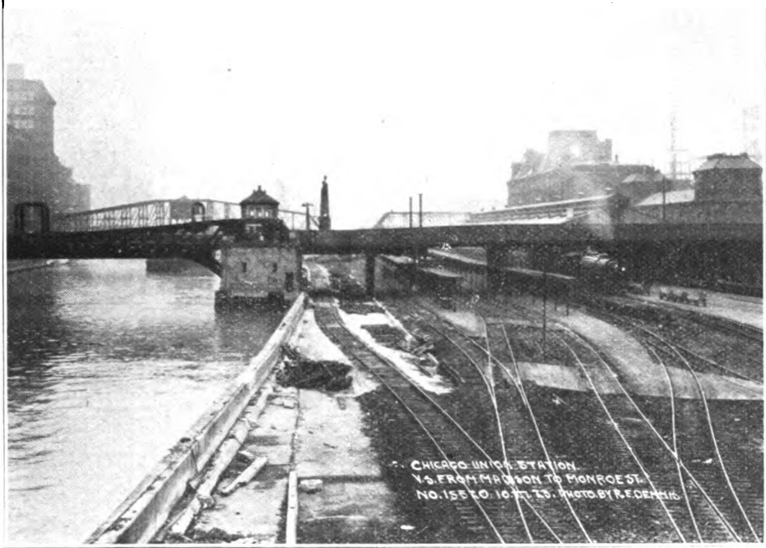
The work had now reached the stage where a portion of the old depot on Canal Street, between Jackson and Adams, where mail and baggage were handled, was in the way and must be removed and a new location found for handling mail and baggage.

This problem was solved by utilizing two old Pennsylvania freight houses situated along the river, which had been vacated. The house between Jackson and Van Buren Streets, known as the "Dairy House" was used as a temporary mail building until the new Mail Terminal was completed by the end of 1922, while the other house between Jackson and Adams was altered to take care of the baggage and express.

With the removal of the old baggage and mail building, Canal Street was closed to traffic between Jackson and Adams Street and work started on the viaduct and additional foundations for the Headhouse, required by a change in plan. A temporary wooden sidewalk was constructed along the side of the old trainshed to accommodate pedestrian traffic and provide access between the old depot at Adams Street and the temporary annex station at Jackson Blvd.

The construction of the new Heating Plant was also started at this time. This plant had to be completed before the old power plant at Madison Street could be wrecked and in time to serve the new Mail Terminal Building when it was ready for operation.

At the north end of the station, the new Butler Brothers' Building at Ran-

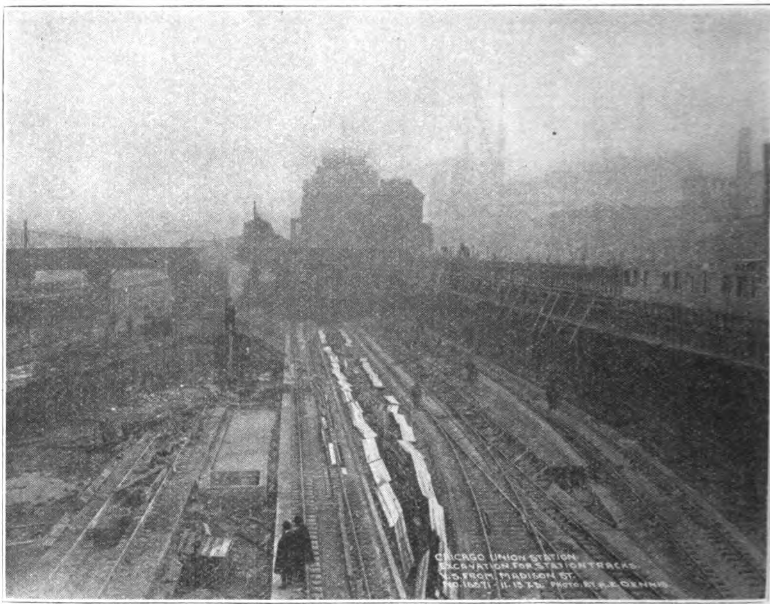


DOCK WALL COMPLETED AND TEMPORARY THROUGH AND STATION TRACKS IN SERVICE.

dolph Street having been completed, the construction of the new approach tracks between Lake and Washington Streets was started. These tracks were located west of the old mains and could be built without interfering with traffic. During the construction of the Randolph Street viaduct however, it was necessary to lower the two main tracks about two feet under traffic.

The construction of Madison Street viaduct was next on the program, since the Washington Street viaduct had been to the station tracks reconstructed. The foundations for this viaduct were all built without interfering with street traffic; the caissons and foundation girders being built by tunneling under the filled approach and abutments of the old viaduct. The superstructure of this viaduct was built while the City had the street closed to traffic in connection with the erection of the new bridge over the river. A temporary foot bridge was provided for pedestrian traffic.

Soon after the completion of the Madi-



PERMANENT STATION TRACKS BEING LAID IN NORTH YARD, CANAL STREET AT RIGHT.

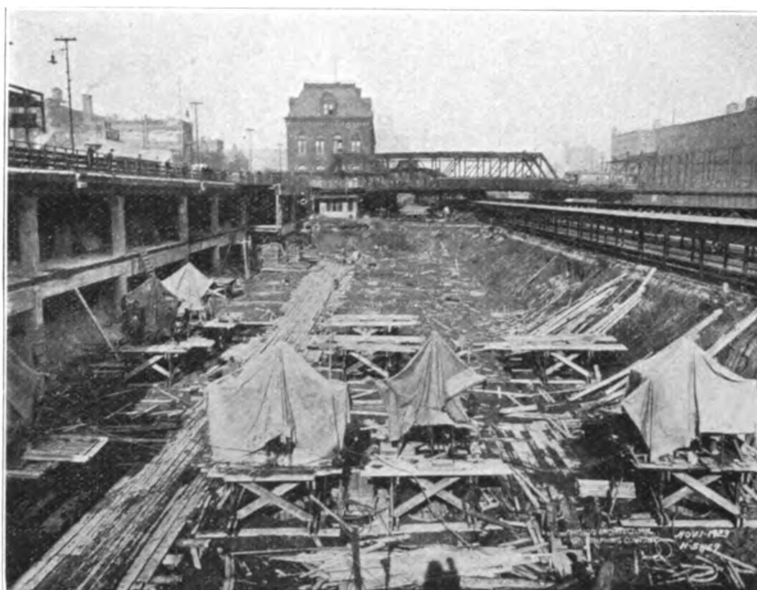
rebuilt previously to conform to the new track arrangement. Preliminary to the construction of this viaduct, the old freight houses were torn down along the river between Madison and Adams Sts.; the new dock wall built, and five temporary station tracks constructed. These tracks were laid at the new grade under Madison and Monroe Streets and substituted for several short station tracks along Canal Street which were in the path of construction operations.

At Madison Street, quite extensive track changes had to be made; the old interlocking plant was abandoned; the two main tracks lowered and the ladders son Street viaduct, the new Mail Terminal Building and Heating Plant were finished and placed in operation. With these new facilities in service, it was possible to abandon the old power house and the old station buildings between Madison and Monroe Streets used for handling C. M. & St. P. Ry. mail.

This cleared the site for the construction of six new station tracks along Canal Street from Washington to Monroe Street. In order to build these tracks on their permanent alignment at Washington Street, it was necessary to cut 30 feet off the rear of the Mead Cycle Building; also at this street, there

was a utility tunnel under the river which had to be extended about 80 feet. This tunnel carried the West Side trunk lines of the telephone company, and the high tension cables of the Commonwealth Edison Company. These obstructions caused considerable delay with the result that the north approach tracks and the station tracks along Canal Street were not completed until the end of 1923.

Upon the completion of the new Mail Terminal Build'ng by the end of 1922, the old "Dairy House," which had been in use as a temporary mail building, was torn down and work started on the construction of station tracks on the east side of the old mains between Harrison and Jackson Boulevard. The re-building of the elevated railway viaduct was also started at this time as the masonry piers of the old viaduct spans seriously interfered with the new track layout. The reconstruction of this viaduct had to be carried on without interfering with the elevated railway traffic or the railroad traffic below, and for this reason was a very difficult and slow operation. At this stage of the work, a change was made in the construction program. The original plan contemplated completing the station tracks east of the mains to Jackson Boulevard and placing same in service before disturbing the old tracks. Instead of following this program it was decided to connect up the old station layout between Jackson and Van Buren Streets with two of the completed new station tracks east of the mains and divert traffic over these tracks to Harrison Street. With the making of these track changes the site was cleared for the completion of the station tracks from Harrison to Jackson Boulevard and the erection of the two center spans of the Van Buren Street viaduct.



EXCAVATING FOR THE NEW CONCOURSE. PASSAGEWAYS UNDER CANAL STREET AT THE LEFT AND TEMPORARY SHELTERS LEADING TO TRAINS AT RIGHT.

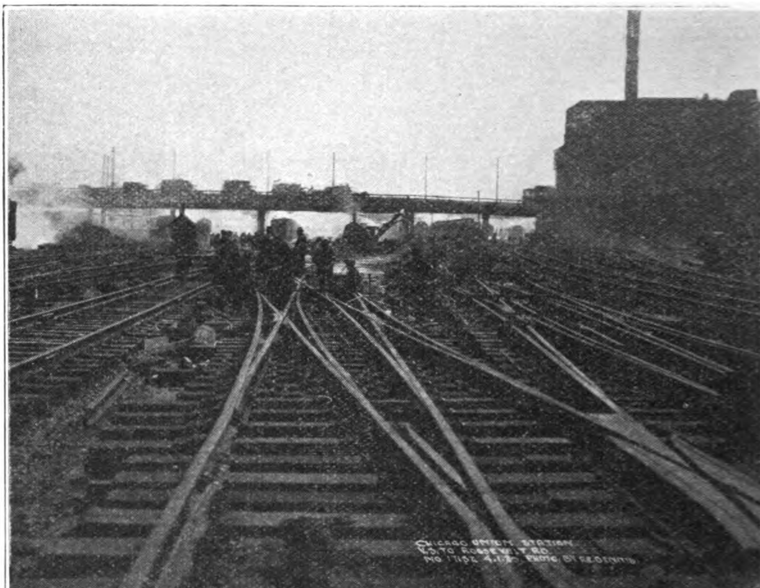
This change speeded up the construction work to a great extent as it permitted more operations to be carried on simultaneously. In fact, at this time, and throughout the year of 1923, the construction operations reached their peak. In addition to the extensive track and viaduct construction, the erection of the Headhouse Building was in full operation, as well as the C. B. & Q. Freight House erection. The installation of the signal

and interlocking facilities was also started.

What might be termed the critical point in the handling of traffic was reached when it was necessary to commence the construction of Jackson Boulevard Viaduct and Concourse Building, which were located in the very center of the old station layout. Before this work could be started, it was necessary to find another temporary location for the baggage and express that were occupying the old freight house along the river. Facilities were provided for handling the baggage on Canal Street in the north end of the old depot by constructing an addition to the rear of the building under the old train shed. Temporary quarters were provided for the express at Canal Street near Harrison. The old freight house was then wrecked and excavation commenced along the river. At the same time, the old train shed was removed and work started along the Canal Street side. Three of the old station tracks and platforms across the middle of this block had to be kept in service until some of the temporary station tracks at the north end had been extended to Washington Street so that the Milwaukee railroad trains could be stopped at Adams Street and also until the permanent through tracks along the river had been completed between Adams and Jackson Boulevard. This was accomplished by the end of 1923 and all the tracks removed from the site of the Concourse Building. A temporary passageway was built between the old station and Jackson Boulevard to handle the passengers. This facility had to be moved three different times during the progress of work on the Concourse Building.

The erection of the Jackson Boulevard viaduct was next started and also the construction of the trucking tunnel along the river between the Mail Building and Concourse Building. A record for speed was established in the building of the Jackson Boulevard viaduct. The old structure was removed and the new superstructure completed ready for traffic in the remarkably short period of 48½ working days. This viaduct and the trucking tunnel were finished in the latter part of 1923.

As previously stated, the north approach tracks, together with the six new station tracks next to Canal Street were completed as far south as Monroe Street at



THE POINT OF GREATEST CONGESTION WAS HERE AT THE ENTRANCE TO THE COACH YARDS NEAR TWELFTH STREET.

the end of 1923. After these tracks were in service, the completion of the remaining four station tracks in the north yard was undertaken. This work had to be done in two operations as two of the tracks had to be built and placed in service before all the old station tracks could be removed. The new Monroe Street viaduct was built at the same time and in conjunction with the construction of these four station tracks which were completed to Adams Street, all the above work together with the north joint tracks between Madison Street and Lake Street was completed by the middle of 1924.

Work was next started on the construction of the superstructure for the south half of the Roosevelt Road viaduct; the foundations and approach for which had been completed in 1920. This viaduct was to be 118 feet wide and the south half could be erected without interfering with the old viaduct. Some extensive track changes were required to clear the site for the new viaduct. It was necessary to lay a temporary main track behind the east abutment of the old viaduct span. This track was laid in a tunnel made through the fill. The traffic conditions were exceptionally bad at this point as both the Pennsylvania and Burlington R. R. coach and freight yards were located here, and the old viaduct span formed a bottle-neck through which all switching to these yards, as well as main-line traffic had to pass. After the south half of the viaduct was placed in service late in the fall of 1924, the old viaduct and filled street were removed and the work started on extending the permanent approach and joint tracks from Taylor Street on their new alignment and grade under the viaduct and connecting them up with the existing tracks south of Roosevelt road. This was a very slow and tedious process on account of the traffic situation and the adverse weather conditions; the work being kept going through the winter. Access had to be provided to both Pennsylvania and C. B. & Q. coach yards and the C. & A. freight house layout at all times. The tracks had to be laid and connected up one at a time, working from the east side to the west. This work was completed in the Summer of this year. The

STEEL FOR THE TRAIN SHEDS WAS ERECTED BY A TRAVELLER MOVING ON THE STATION TRACKS.

erection of the north half of the viaduct at Roosevelt Road was begun in April of this year and has just been completed.

The erection of the train shed steel was started in the Fall of 1924. This steel was erected with a traveller operating along the completed baggage platforms. The station tracks on each side of the traveller were sacrificed to the Contractor for the handling of steel.

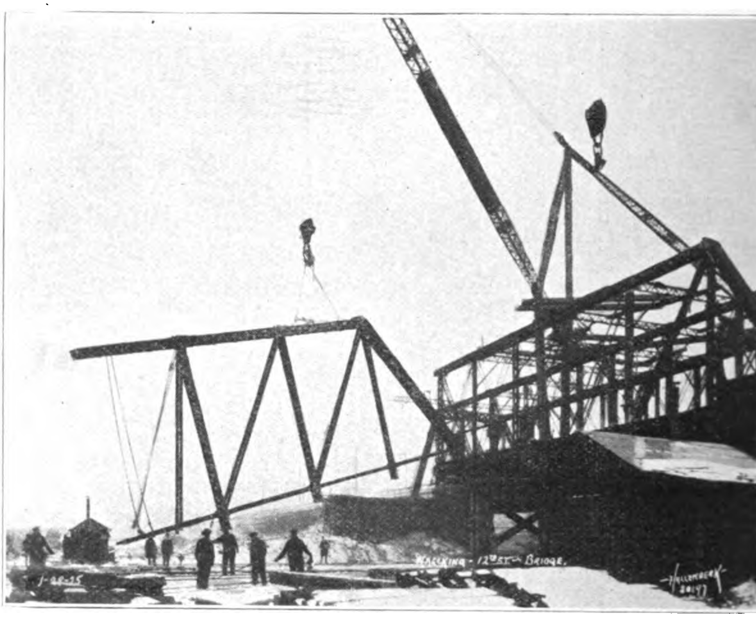
There was no other interference with station traffic during this work and all of the passenger platforms were kept in service, the temporary umbrella canopies affording protection from the work overhead. This scheme for handling the train shed erection has proven very satisfactory. The concreting of the train shed has been handled from the various viaducts without interfering with railroad traffic; except that the tracks have been utilized in placing the forms and for receiving the cement tile roofing. The train shed will be completely finished at the end of this year.

As fast as the train shed is erected, the temporary umbrella canopies are to be removed and the finished concrete slab placed on top of the passenger platforms. The tracks on both sides of a platform are taken out of service during this work. The mixing of the concrete is done on the viaducts.

The new station and concourse were placed in service on May 16 of this year. The moving from the old depot into the new quarters was started at midnight and completed at 7:00 A. M. This transition was very efficiently accomplished by the operating forces without interruption to traffic or inconvenience to patrons of the station. The vacation of the old station building removed the last obstruction to the completion of the project. Work was immediately started on the extension of the tracks, platforms and train shed along Canal Street to Adams Street. At the same time, the raising and widening of Canal Street between Monroe Street and Adams Street and the construction of the new Adams Street viaduct was begun. This work is now being vigorously supervised and will all be finished by winter.

The entire improvement, with the exception of the track and signal work north of Lake Street and a few odds and ends will be finished this year.

Throughout the progress of the Con-



REMOVING THE LAST SPAN OF THE OLD TWELFTH ST. VIADUCT.

struction work, which has extended over a period of approximately 10 years, no effort or expense has been spared in protecting and safeguarding the interests of the public and patrons of the railroads. Temporary facilities have been liberally provided. As a result of these precautions, there has not been a single case of serious physical injury to a passenger or to the public caused by construction operations.

In conclusion, the credit for the successful handling of traffic on this project should be given to the Station Master and his assistants. These men have accomplished wonders in operating the station with greatly reduced facilities during the construction period and have given hearty co-operation to the construction program at all times.

Acknowledgement is also given to the Engineering and Operating Departments of the Pennsylvania Railroad, C. B. & Q. R. R., C. M. & St. P. R. R., and C. & A. R. R. respectively, for the assistance and cooperation received from them during the construction operations.

Tracks and Track Layouts in the Chicago Union Station

By Clarence J. Noland,* M. W. S. E.

Presented October 12, 1925

Extreme care in the design of the track work in the new Union Station has resulted in equipment having maximum flexibility in operation and giving excellent service, as shown in this paper. Care has been used throughout to avoid using material of special manufacture wherever possible. This is one of the specialized features of the project which contributes largely to its success. The design and installation of the track work presented some knotty problems for the engineers.—Editor.

Trackwork and Its Design

IN the early stages of a terminal, the track layout is the one big, important item. Upon it depends the successful operation of the other necessary facilities, which as the work progresses, gradually assume greater prominence until finally if the track layout has been properly designed, its importance is sometimes overlooked.

The earlier studies for a new Union Station Terminal at Chicago are fully described in another paper. They bring out very clearly the fact that our present track layout was the result of many studies, each one of which had its own merits, but more forcibly that the solution to any important terminal should only be arrived at by careful study from many viewpoints, and by the process of elimination arrive at a satisfactory plan.

It was in this way a plan was developed in 1915 having tracks in pairs, with high platforms, elevators and a subway system for handling baggage which was adopted as a basis for working up details. This plan, however, was not put into effect, principally on account of war conditions which required the Station Company to suspend operation.

At the conclusion of the war, other conditions had developed which required a restudy of the track layout. It was found necessary to make different provisions for the mail facilities, which in turn released additional space for station tracks. Our former plan had proposed two tracks each in the north and south yards along Canal Street for the use of mail, with facilities along the driveway between Adams Street and Jackson Boulevard for the accommodation of trucks handling mail to and from the Station by chutes and elevators to a space reserved in the basement.

The new conditions were such that the mail facilities were relocated in the space formerly proposed for the express between Van Buren and Harrison Streets,

* Office Engineer, formerly Engineer of Tracks, Chicago Union Station Co.

east of the station tracks, and it was then possible to reconsider the station track layout.

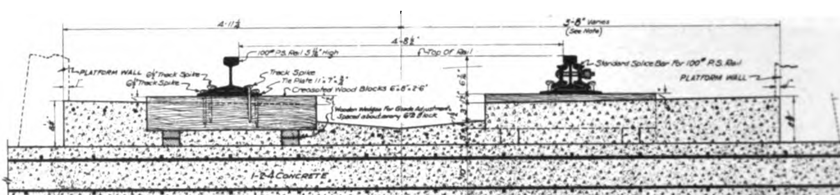
The earlier studies developed the fact that it would be very desirable to have separate platforms for the handling of passengers and baggage, but due to the restricted space it was not thought advisable to sacrifice tracks to obtain it. Now that two additional tracks in each yard were available for passenger use, it was possible to respace the tracks by absorbing the space occupied by one of these mail tracks and introduce separate passenger and baggage platforms.

This plan was carefully considered and as finally adopted, provided for a baggage platform 10 ft., 7 in. in width between each pair of tracks and passenger platforms 13 ft., 9½ in. in width, or 21 ft., 6 in. and 23 ft., 3 in. respectively, between track centers. At this time the question of high vs. low passenger platforms was settled. Our earlier studies were made on the assumption of high passenger platforms. It was found, however, that it would be very expensive to change the equipment of some of the railroads and their affiliated lines to be adaptable to facilities which only a very limited amount of the equipment of some of the roads would use, so passenger platforms 7¾ in. above top of rail were decided upon.

The height of baggage platforms was arrived at by considering the type of baggage truck we proposed to use and after experimenting with full sized working models from which baggage was actually handled to and from trucks and cars, a height of 20 in. above top of rail was decided upon as being the most desirable for all types of baggage and mail handling.

The separate passenger and baggage platform arrangement eliminated the necessity for a subway system connecting with the outer ends of the platforms as it was very easy to arrange trucking ramps connecting with the baggage room and baggage platforms. We did, however, provide a subway connecting the Power House and Mail Building, which was primarily for the accommodation of the heating system. The easterly portion was widened sufficiently for trucking space and connections by elevators were made to the three easterly baggage platforms, principally for use in delivering mail to outbound trains. The Mail Building and Baggage Room are also connected by a subway which is used for the heating system from the Power House to the Station and made wide enough to permit trucking of mail to and from the Mail Building.

In the preparation of our track studies, it was necessary to have definite limiting clearances. This was taken up with the Illinois State Public Utility Commission, a public hearing was held and clearances established which were satisfactory to all interested parties. These were in general as follows: 16 ft. 6 in. vertical, 7 ft. 6 in. from center line of track for side clearance, for approach and ladder tracks; 5 ft. 4½ in. side clearance for station tracks up to 4 ft. 0 in. above top of rail, and 7 ft. 0 in. side clearance above 4 ft. 0 in.



STATION TRACKS WERE LAID ON A CONCRETE SLAB WITH WOOD BLOCKS IMBEDDED IN CONCRETE.

Surveys

It was also found essential to have accurate plans. There were two courses open, one to make a survey ourselves, which from our point of view seemed the economical thing to do. The other was to have a reliable surveyor do the work for us. The relative merits for each method were fully considered and for many reasons it was decided to have an outside concern do the work for us.

and accordingly in the spring of 1913 a Chicago company was engaged to make a complete survey from Carroll Avenue to Roosevelt Road and from Canal Street to the River, except a portion between Madison and Van Buren Streets covering the existing station and station tracks, which had previously been made in 1903.

The survey was platted on a 20 ft.=1 in. scale and all existing buildings, tracks, viaducts, bridges, street lines, blocks, lots, old street lines, utilities in streets where possible to get from records, street elevations and such other additional information as could be obtained from City records, was indicated on the drawings. The survey was tied up to a semi-permanent base line on the west sidewalk of Canal Street.

In order properly to close up the north survey extending from Madison Street north with the survey extending from Van Buren Street south, the surveying company made a base line survey between the above streets, thus giving us a continuous survey by one party covering the extent of our improvement. These surveys were submitted to the City and approved by the proper City officials.

In 1914 and 1915 additional surveys were made by the same company so that finally we had a complete survey made by one party covering our entire improvements from Kinzie Street at the north to 16th Street at the south. From the above as a basis, our Engineers established a base line in Clinton Street and a temporary base line on our property between Harrison and Madison Streets. All the tapes used on this work were calibrated from the standard at the City Hall. Temperature adjustments were made and instrument work was done in the early mornings and on Sundays when the streets were comparatively free from traffic.

The base line on Clinton Street was monumented by placing copper plugs in the sidewalk and well referenced, as both the lines in Canal Street and on our property would be disturbed by our improvements. The base line on our property was relocated several times as the work progressed and the line on Clinton Street was used as a check on the new locations.

We found during the latter part of our work some of the monuments in Clinton Street had been disturbed, but our work had then reached the stage where established points could be picked up on the completed work, and it was not considered essential to relocate the monuments. From this survey we laid out a system of rectangular coordinates establishing the zero lines far enough west and south to cover the entire improvement. The east line of Canal Street between Harrison and Madison Streets was used as the basis for the east and west co-ordinate, and the zero for the north and south co-ordinate was established south of Roosevelt Road. A separate plan drawn to a scale of 100 ft.=1 in. was prepared showing co-ordinates for all street intersections and property lines. This was used as a basis in laying out the various viaducts, buildings, trackwork, utilities, etc., for the entire project.

With the above data collected and established we had a good foundation laid for the preparation of working plans.

Station Plans

The final layout was made up of two stub end terminals, 14 tracks at the south and 10 tracks at the north, with a connecting track lying between the Concourse and River.

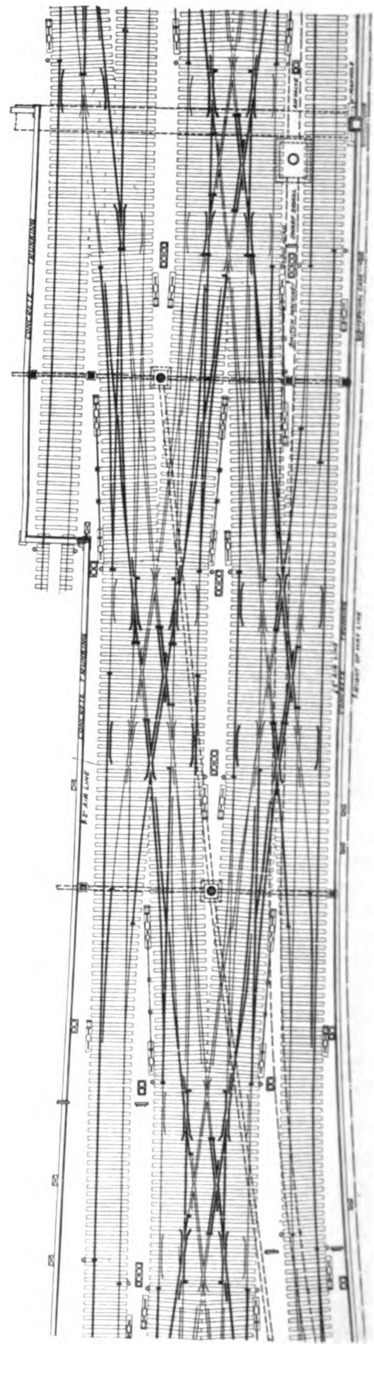
The car capacity of the south yard is 191 seventy-foot cars. The individual track capacities vary from 7 to 18 cars. For the north yard the car capacity is 141 seventy-foot cars and the individual track capacities vary from 9 to 18 cars, allowance being made for a locomotive on each track. The south station tracks by means of a double ladder on the west side connect to six main approach tracks extending to Roosevelt Road, the south limit of the improvements, where they join with four tracks owned jointly by the Pennsylvania and the Chicago & Alton, and two tracks owned by the Burlington, and also with the passenger coach yards of the Pennsylvania and Burlington to the east and west of the main tracks, respectively. There are double cross-over ladders between Harrison Street and Polk Street and between Taylor Street and Roosevelt Road which al-

lows the maximum flexibility of train movement.

The north station tracks in a similar manner were designed to connect with six approach tracks extending beyond Fulton Street, the north limit, where they join with two tracks owned jointly by the Pennsylvania and the Chicago, Milwaukee & St. Paul extending to the west and with a branch line of the Milwaukee extending to the north. There were, however, only four approach tracks installed at the north end, extending to Lake Street where they merge temporarily into the two existing main tracks.

The station track ladders, from which the station tracks connect in pairs, were laid out with the view primarily of getting maximum capacity. In the north yard the location was dependent upon providing clearances for the columns supporting the Madison Street viaduct and full advantage of the ladder angle was not obtained. However, in the south yard the only limiting conditions imposed were the columns for the Harrison Street Viaduct, where the ladders join with the approach tracks, and the angle found to be the most suitable for capacity was determined by connecting the inner station track to ladder, using the theoretical radius of a No. 8 turnout, and making the central angle such as not to exceed the turnout radius for the outer track. This allowed placing the switch points 2½ ft. back of the heel of frog on ladder, which was about the limit to allow proper tie spacing at the point. It also allowed the actual turnout radius not to be exceeded in the connecting tracks, when later computed. The angle found to be most satisfactory was 19°-12′-30″.

In the early stages of our work a diagram was prepared, charting graphically the train movements in and out of the station, together with all the necessary switching for the peak hour 7:30 to 8:30 A. M., allowing space on tracks for each train and timing movements through the various crossings so as to have no interference. It was found we could theoretically accommodate all the trains on about one-half of the station tracks. This proved interesting to compare with a similar diagram prepared this year from actual working conditions. We found that



PLAN OF A TYPICAL CROSSOVER.

due to connections not being fully made to the coach yards at Roosevelt Road, practically all train movements were being made over two approach tracks, and that trains were being held unnecessarily long on the station tracks. However, the diagram showed very clearly that our former assumptions were correct in that our station tracks could accommodate 50% more trains. The present train schedule for the peak hour takes care of 41 inbound and three outbound trains, with the necessary switching movements, or 265 trains and 1310 switching movements in and out of the station per day.

The 20 ft.=1 in. drawings were used as a basis for preparing the detail plans, etc. On these drawings the co-ordinates were carefully plotted. All existing buildings, tracks and structures which were to be removed were located on the back of tracings by light lines, leaving the top of tracing free for the proposed work. This proved very satisfactory, especially in the planning of our work.

The trackwork was figured and plotted with reference to the co-ordinate system. A complete list of all curve data tabulated on each sheet, with co-ordinates indicated on plan for all turnouts, slips, crossings and curve intersections, so that with these plans it was possible to start work at any point in the yard with the assurance that later it would fit in properly with other units and due to the restricted space we had to install our new work, it was actually done along these lines.

The track grades were practically decided for us by the viaducts crossing the tracks and the trunk line sewers at Washington, Harrison, Polk, Taylor and Roosevelt Road.

The approved overhead clearance of 16 ft. 6 in. was not considered sufficient to provide for future electrification and it was increased to 17 ft. 0 in. This gave us slightly less than 12 in. from top of rail to top of sewer at Washington and Harrison Streets. The low point in the south yard was Van Buren Street, which established a descending grade north from Harrison Street to Van Buren Street of 0.4%, and an ascending grade to the concourse of 0.37%. In the north yard the low point was Madison Street,

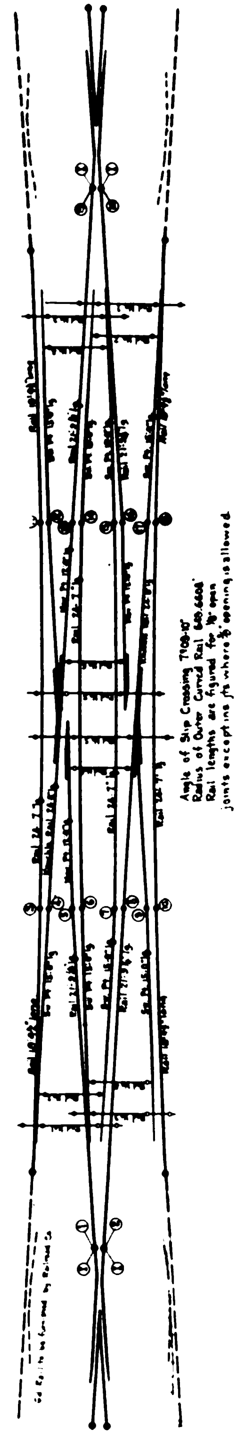


DIAGRAM OF A NO. 8 SLIP CROSSING SHOWING RAIL LENGTHS, JOINT NUMBERS AND ROD NUMBERS.

purposely made to prevent street changes at the Northwestern Station and required the westerly tracks to be placed at elevation —2 ft. The tracks were stepped to the east, taking up the variation in the baggage platforms.

The established grades north from the Concourse descend on a 0.37% grade to Monroe Street, then by a series of grades varying from 0.9% to 0.31% to Madison Street and ascending by a series of grades varying from 0.85% to 0.4% to Washington Street.

The general working drawings were laid out on a ⅛-in. scale, and in order to assure ourselves we also laid out all the station track ends where they connect with the ladders, and all the crossovers and ladders on a ¼-in. scale On these drawings, we ran a car template over the tracks, plotting the continuous middle ordinates and end overhang at all places where the question of clearances was involved. This enabled us to locate accurately the edge of platforms, columns, signal apparatus and structures of all kinds, which were limited by track clearances. They also enabled us to locate the insulated joints at the fouling points and all kinds of utilities where limiting clearances were involved.

The station tracks were laid with 100-lb. P. S. rail on 7x11x¾-in. tie plates resting on 6 in. x 8 in. x 2 ft. 6 in. creosoted yellow pine blocks imbedded in concrete with a trough between the inner ends of the two lines of blocks for drainage. The top of this concrete encasement has a ⅛-in. slope towards the trough, leaving about 2 in. clear space under the base of rail between blocks.

The blocks have 3 in. of concrete between the underside and the slab proper with a minimum of 1½ in. at the center of the trough. This construction is supported on a 10-in. concrete slab reinforced both top and bottom, 14 ft. wide and in suitable working lengths.

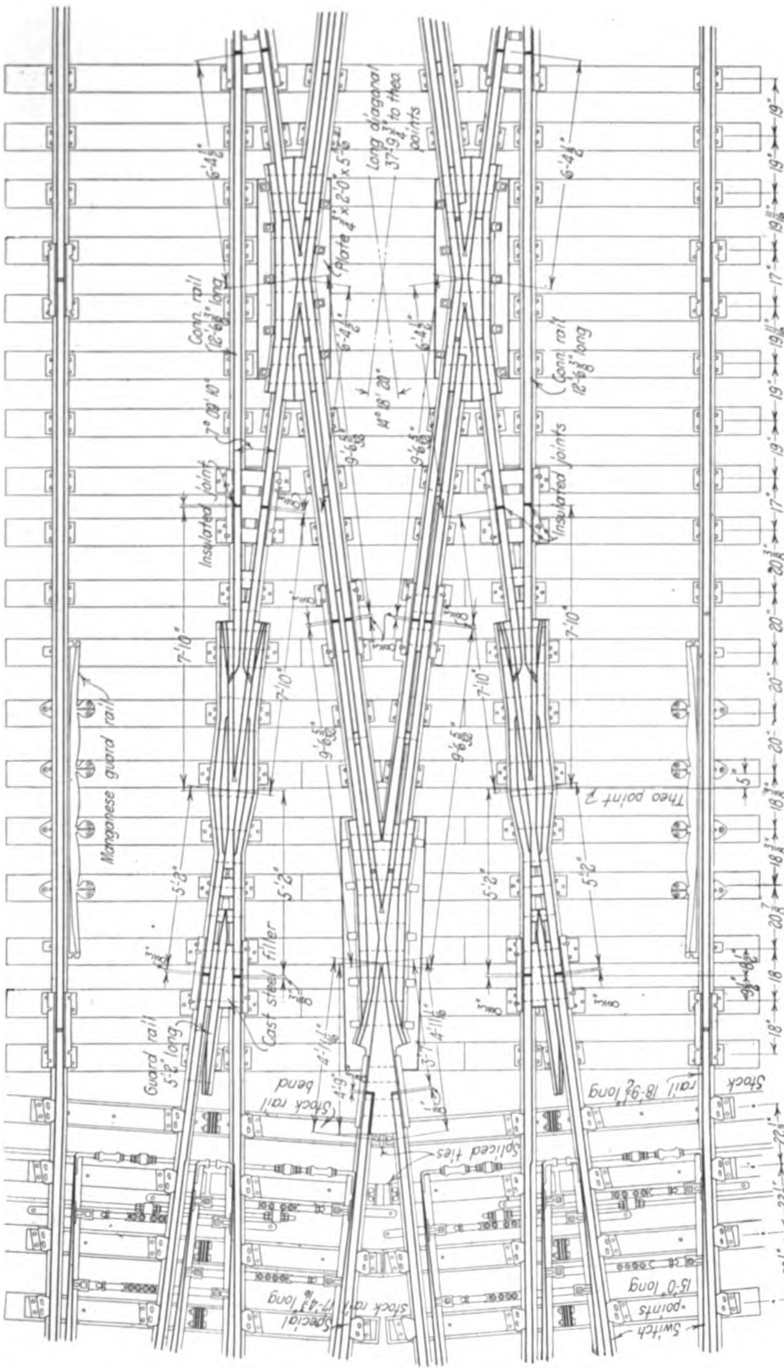
This type of construction extends for practically the entire length of all station platforms. At the outer ends of tracks where they join with the ladders, the concrete work was terminated so as to allow a minimum of 6 in. for concrete at edge of blocks and 3 in. from edge of concrete shoulder to end of cross ties on the ballasted track. In all cases we provided a ballast stop where the two types of construction joined.

At the beginning of our work we had provided only for the concrete slabs carrying the tracks, with an intervening gap between the slabs and under the platforms. We found among other things this opening allowed surface drainage to get in under the track slab and in some cases allowed a pumping to occur as trains passed over the tracks. Plans were changed to fill in this space with plain concrete and no further trouble was experienced.

The type of track construction as used in our station is similar to that used at the New York terminals and was arrived at after we had made a number of studies none of which proved as satisfactory as the one we adopted. The main advantages of this type of trackwork are the neat appearance, ease with which it can be kept clean and its permanence. We also used this type of construction on 9 of our turnouts, which were located at points where it was not desirable to use the ballasted type of construction. The blocks have no anchorage, relying entirely on the adhesion of the concrete to the blocks, and regardless of the fact that some of this trackwork was used for heavy freight traffic during the construction period, it has fully met our expectations.

The ladder and approach tracks including the turnout slips and crossings were laid with 130-lb. P. S. rail on 7x9-in. cross ties 8 ft. 6 in. long and 8x10-in. ties 21 ft. 6 in. long at the crossings. A concrete slab extends from Lake Street to the north station tracks and from the south station tracks to the limits of the crossover systems between Harrison and Polk Streets, and under the crossover system between Taylor and Roosevelt Road, leaving a comparatively short portion of the south approach tracks between Polk and Taylor Streets on standard ballasted construction. The grade of the approach tracks was not sufficient to provide proper drainage. This was obtained by making a series of peaks in the slabs, normal to the tracks, approximately midway between drain inlets, allowing a minimum of 6 in. for ballast under ties, and sloping each way to the inlets, with a maximum of 10 in. for ballast under ties.

The cross ties and switch ties were of



PART PLAN OF A TYPICAL DIAMOND CROSSING.

red oak, some being zinc treated. The majority however, were treated by the empty cell process with No. 1 A. W. P. A. oil allowing a retention in the ties of not less than 8 lb. per cubic foot. The blocks were mostly short leaf yellow pine. We tried some red oak blocks, but they did not prove entirely satisfactory, due to bad checking. In the last order of these blocks the timber was not properly air seasoned, and the so-called Boulton Vacuum process was used. The results appear to be better than our previous orders, where the timber was fully seasoned before treatment.

Drainage

A drainage system extends over the entire improvement. For convenience it is divided to cover south approach tracks, station tracks and north approach tracks.

In the south approach tracks, between Harrison Street and Roosevelt Road, the drainage system connects with the trunk line sewers at each of the intersecting streets; the mains are of 12-in. vitrified tile and the laterals, located approximately 85 ft. apart, are of 8-in. vitrified tile with open joints. Precast inlets 20x28 in. with varying depths are located between tracks, the tops being about 3 in. below base of rail. At the north and south sides and tops of these inlets are 14x16-in. cast iron gratings, the side gratings to take drainage at sub-grade and the top grating for use in winter when ballast is frozen or as occurs when ballast becomes well packed with dirt and cinders.

The main trunk line sewers were very close to our tracks and did not allow this system to be located at a desirable depth. At present it is not giving entire satisfaction, as some of the laterals are closed, due probably to sediment being forced through the joints from the pump action caused by passing trains.

The drainage between Harrison and Washington Streets, covering the station tracks was a different problem. The tracks at Van Buren and Madison Streets were so low it was necessary to collect the drainage at sumps for each yard and raise it to river level by automatic pumps. There are two mains in each yard, running practically the entire length.

Laterals approximately 85 ft. apart connect the mains with the track inlets. In general two types of inlets were used, one in ballast and between tracks similar to those used on approach tracks, and a cast iron inlet with a concave grating between the rails in the concreted track construction.

It was necessary to syphon under the cross subway in the south yard and the trunk sewer at Washington Street. Manholes were provided at all lateral intersections for future needs in cleaning out the system.

Cast iron pipe with caulked joints was used throughout for this section. The mains varying in size from 12 in. to 20 in. and 8 in. for the laterals.

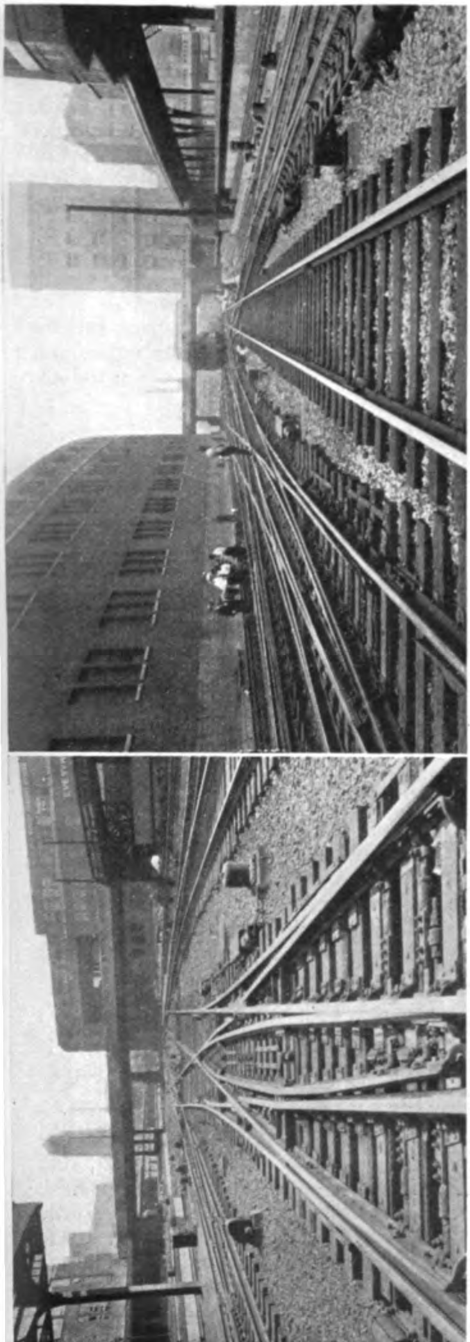
A separate drainage system was provided for the trainsheds with a direct connection to the river, and a 4-in. bypass connection to the sumps for the purpose of draining the system. Check valves were provided to prevent back flow from the river and seal covers for manholes to protect the tracks from any head which may occur in the system.

The sump in the south yard is located near Van Buren Street and the Mail building. It is a reinforced concrete structure 24 ft. long x 12 ft. wide x 17 ft deep, and takes all the track drainage from Harrison Street to the Concourse The pumps, which operate this sump are located in the basement of the Mail building.

The sump for the north yard is located south of Madison Street and near the River. It is 33 ft. 6 in. long x 12 ft. 4 in wide x 16 ft. 4 in. deep, the roof forming a part of the platform. An enclosed space 15 ft. long x 12 ft 4 in. wide x 7 ft. deep is provided for the pumps and takes the drainage for north approach and north station tracks.

The area requiring pumpage and not covered by trainshed or other roofs is approximately 146,000 sq. ft. for the south yard and 266,000 sq. ft. for the north yard. In addition the trainsheds and concourse roof drainage which is dropped by downspouts to the track level gives an area of 443,000 sq. ft. and 120,000 sq. ft., respectively, or a total of nearly 1,000,000 sq. ft. of drainage area. A rainfall of 1 in. in 15 minutes over this area would amount to 40,000 gal. per minute.

In order to determine the sump and pump capacities, a curve was plotted showing maximum rainfall in Chicago as



TWO VIEWS OF THE DOUBLE SLIPS INSTALLED IN THE SOUTH YARD.

taken from the weather bureau records for a given elapsed time. Other curves were prepared showing the maximum runoff for given areas, assuming 30 minutes, 1 hour and 2 hour periods, and in considering the various areas a runoff period was taken which allowed for the average distance the water had to travel, character of the drainage surface, etc. On this curve for a given area the capacity of sump was shown and various pumpage lines drawn, from which the capacity of sumps, pumps and pipes was determined. Due to the delay in water reaching the sumps, pumps of moderate size were found to be sufficient, as the problem was one of capacity to handle a uniform load of comparatively short duration.

Two 1200-gallon per minute horizontally split motor driven centrifugal pumps, furnished by Yeomans Bros., were used for the sump in the south yard, and two motor driven Worthington pumps of 2000-gallon per minute capacity each for the north yard sump. The pumps are below river level and discharge under a head, hence they are kept primed and it was possible to omit the foot valves on suction pipes in the sumps.

The pumps are controlled automatically by float switches and in addition there is a float switch alarm which acts in case of failure of pumps to keep water below a certain level.

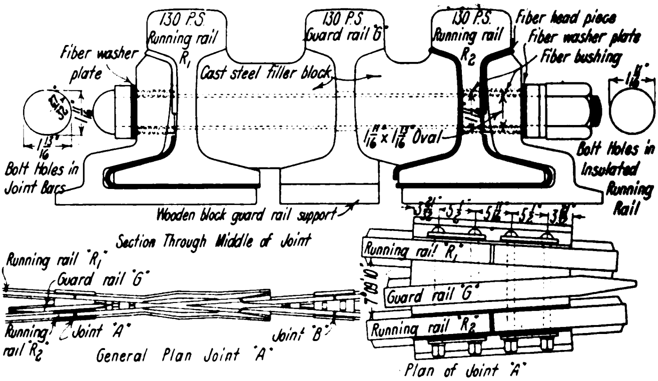
The drainage for the north approach tracks was designed to extend to the north limits of the improvement, for the present it ends at Lake Street. The system is similar to that used in the south approach tracks, except the concrete track slab extends to the north limits of the trackwork. The system is located at a suitable depth, in which we considered 5 ft. below base of rail as a standard, with a 0.5% grades for laterals and a minimum of 0.25% grade for the mains. Vitrified tile mains and laterals were used north of Washington Street. South to the sump at Madison Street the mains and laterals are of cast iron with caulked joints and from a part of the station track drainage.

Track Details

In all of the track studies, one of the requirements was to avoid special work. No. 8 turnouts and slips were taken as the prevailing standard, the exception be-

ing the cross over system at the south limits connecting to the coach yards where No. 9 turnouts and slips were used and a few No. 7, No. 10 and one No. 12 turnout were used at special places. Practically all turnouts and slips are of 130-lb. rail.

Standard Pennsylvania plans were used with some modifications for split switches and frogs. We prepared standard plans and details with assistance from the manufacterer for the double slips and crossings. We also tabulated complete data as to turnouts for the computers and field use so that with the co-ordinates given for the theoretical intersection, the location of switch points, frogs and curvature of connecting rails were easily found. This proved very valuable both in the preparation of detail plans and in the field location.



TYPE "A" INSULATED JOINT USED WITH SHORT GUARD RAIL.

Turnouts

The No. 8 turnouts have a 70-ft. lead; 18-ft. switch point and 6½-in. spread at heel, 4½-in. throw at points, 13 pair of plates, cast steel heel blocks and three pair of adjustable braces. The 130-lb. rail required the angle bar on gauge side to be bent and a thimble on front bolt to allow proper tightening of bolts and free movement of points. The plates were 7-in. wide from 1⅛-in. stock, planed to ¾-in. for stock rail, $\frac{1}{16}$-in. to $\frac{5}{16}$-in. for risers and of varying lengths. The 130-lb. rail was spiked to the turnout curve of 12°-10′ without being previously curved.

The frogs are cast manganese centers, rail bound with cast steel heel and toe blocks, 2¼-in. throat and 1¾-in. flangeways. One-piece cast manganese guard rails 8 ft. 6 in. long were used throughout. Many of these guard rails have been in use at the south entrance to yard for over five years and show very little wear.

The double scissor crossover systems at the outer ends of approach tracks and at the entrance to station tracks cross the main tracks which are on 13-ft. track centers. The diamond crossings have either two double slips or a turnout and slip at each end, and required the end frogs of crossing to join with the stock rail of slips.

It was necessary to place a guard rail in the toe end of slip frog to protect the end crossing frog. This was accomplished by using 13-ft. end frogs for the slips and a split filler with a 5-ft. 2-in. guard extending 3 ft. 3 in. beyond the toe of frog, fastening the end to stock rail of slip. The crossing frogs are cast manganese rail bound, continuous guard, 4-ft. 8½-in. guage with 1¾-in. flangeway. The end frogs as well as the center frogs are interchangeable. The end frogs with wing rails are 13 ft. 5 in. long, center frogs 15 ft. 10 in. long and the four frogs weigh approximately 17,000 lb.

Double Slips

Considerable study was given to this part of our work, the object being at all times to work up a design which would be considered a masterpiece in trackwork. We found that due to using 130-lb. rail it was necessary to have heavier construction throughout and we had very little precedent to follow. Full sized draw-

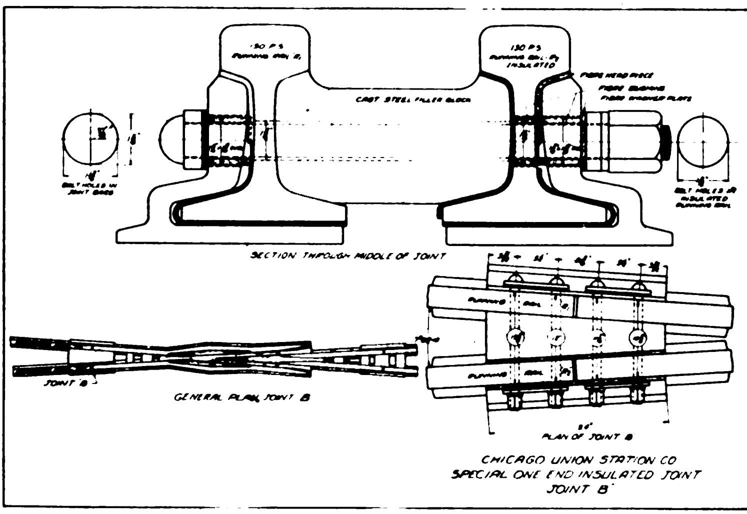
ings were made of the end points, movable points and connections, and locations determined. The stock rails connecting with end frogs were notched ¼ in. to protect the switch points and at the same time allow them to be placed at the extreme limits.

In the No. 8 double slip, 15-ft. switch points were used curved from end of head planing to a radius of 649.66 ft., the radius of outer rail for slip, with a 4½-in. throw at points. At the heel of switch points, joints were also made in the stock rails, fastened together by cast steel heel blocks and anchor blocks holding the rails on each side of center line rigidly together. This rests on two 7x1-in. plates extending under the entire row of joints. In addition four anti-creeper straps ¾-in. x2-in. are fastened to rails at joint and spiked to the four ties on either side.

Two cast steel anchor blocks were placed between the easer rails and outer connecting rails which with the braces hold the center of slip very rigid.

The movable points are 12 ft. long, with a 4-in. throw, 8 in. between points, and 3-ft. easer rails. The knuckle rails are 24 ft. 8 in. long with 6-ft. easer rails and the connecting rails are 24 ft. 7 in. long. Four plates at the end points, two at the joints and four at the center points extend under the entire slip. These plates are cut, turned up and bolted with fibre insulation at the center. The other plates are in pairs between the center long plates and joints and under separate rails between joints and long plates for end points. All plates are 7x1 in. planed from solid plate to ¾ in. for stock rail and to ¾ in., ⅞ in. and 15/16 in. for risers, eliminating riveted risers entirely. In all 74 special plates are required for the slip.

Adjustable rail braces made of malleable iron are used throughout. The earlier type we used had a cast steel connecting washer placed under the plates, and a beveled stop riveted to the plate for holding the brace in place. This did not prove satisfactory, first because it was necessary to notch the ties for the washer under plate, second because we had trouble in keeping the bolts which screwed down into this washer tight, and third because the brace itself was in the form of a wedge being driven in place, which in some cases did not allow the brace to be properly centered on plate. We changed to a square headed, countersunk bolt which set flush with the underside of plate and the nut on top. This worked better, but it was difficult to slip the brace in place over the bolts; we later adopted a brace similar to this except eliptical holes at right angles to rail were provided. The outer edge of brace was

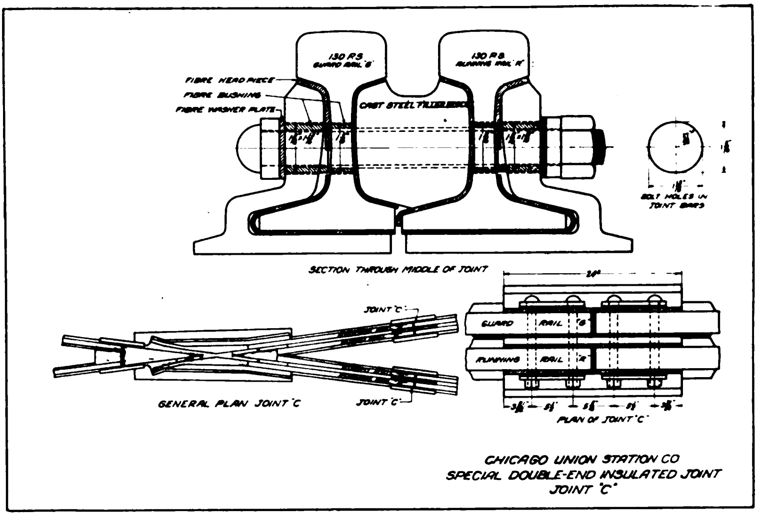


TYPE "B" INSULATED JOINT WITH FILLER BLOCK.

tapered. The stop on plate was set at right angles and a tapered wedge driven in between brace and stop allowing the brace to remain correctly centered on plate. This has proven very satisfactory both as to installing and maintaining. For the standard No. 8 double slip, 76 of these braces are required. The gauge is 4 ft. 8½ in. on straight track, 4 ft. 8¾ in. at switch points and 4 ft. 8⅞ in. on curved track.

The No. 9 double slip is similar in design, except 18-ft. switch points curved from end of head planing to a radius of 859.93 ft. the outer rail radius of connecting rail. The standard slip required 82 tie plates and 84 adjustable braces. We called for ⅛-in. pipe thimbles at the joint bolts for switch points and movable points, to prevent binding when throwing the points. They were not satisfactory. Many of them were battered in the installation and others failed in tightening the joint bolts, so the switch points were either loose and pounded, or tight and bound. Also the cast anchor block was not adjustable and after four years service some of the slips were getting in bad shape. We took one of the worst slips and installed ⅛-in. cast manganese thimbles, with ends accurately ground to correct length, changed the design of the large anchor block by making it in two parts with two tapered wedges slotted for bolting the parts together, made a fishing fit to rails which allows for future adjustment and installed early last fall. The results were so satisfactory that we repaired several other slips in a similar manner, and today slips and crossings that have had 5½ years severe service are, aside from natural wear, tight and in good working condition. Of course, considerable credit must be given to the concrete track slab and the heavy rail.

Some of the outstanding features of the double slips are the extra heavy construction, the manufacturers advise that no other slips have ever been built of as heavy material throughout—the extra precautions taken for firmly fastening the various parts together; the 5½ years service of these slips showing no creepage of points whatever, the complete provisions for future interlocking; the ties were properly spaced and of the right length for later installing the switch machines, the throwing rods were insulated and baskets provided for switch machine connections; the frogs were all provided with steel shims at joints which could later be removed and replaced by fibre insulation; the ease with which the points can be thrown; the manganese thimbles used at the joint bolts allow the joint to be kept

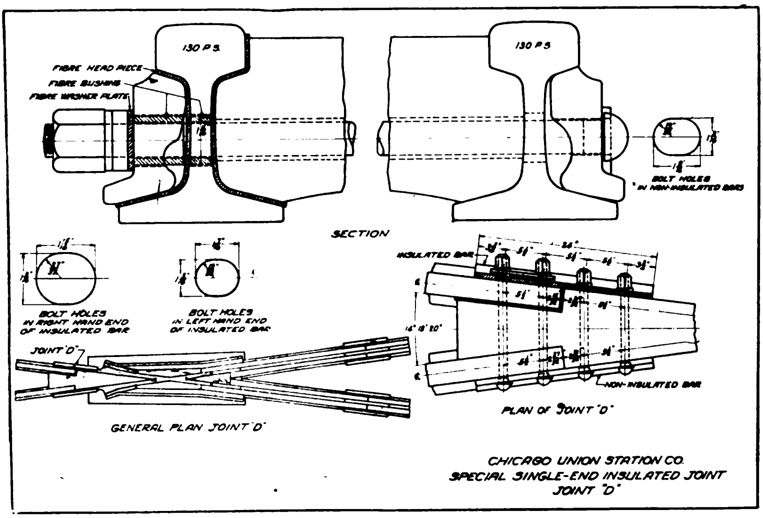


TYPE "C" JOINT WHERE BOTH RAILS ARE INSULATED.

tight and at the same time free movement of the points; the very limited amount of maintenance required; there was practically no maintenance given these slips for the first four years they were in use. The plates, braces, anchor blocks and other parts show practically no wear and will be used again when new points and connecting rails are installed. The extra first cost has been many times paid for in the low maintenance, and the extra long service these slips are giving.

The slips and crossings were first installed at the south entrance to station tracks and had been used for regular train movements by the roads using the south station tracks for about two years, when temporary connections were made to allow the Milwaukee road to use the south mail tracks. The first engine trailing through a slip derailed by allowing the rear trailer wheel to climb the guard rail. We made tests of other slips with their engines and found the same trouble. We were practically ready to open the north yard approach tracks to traffic with the same kind of slips and were at a loss for the remedy. Suggestions were made ranging from widening the present gauge to changing the layout entirely. We did widen the gauge slightly and found it was possible to get their equipment through, but not with any assurance of safety.

We had a high type of guard rail made for experimental use from open hearth steel, equipped one of the slips with these guard rails which were ⅞ in. above top of stock rail and with 1¾-in. flangeway, made another test and found we had solved the problem. We later had these guard rails made of manganese steel similar to the others except for the additional height, equipped all the slips which would be used by this road with this type of guard rail and have had no further trouble.



TYPE "D" INSULATED JOINT WHERE RAIL IS ATTACHED TO MAIN CASTING OF FROG.

Insulated Joints

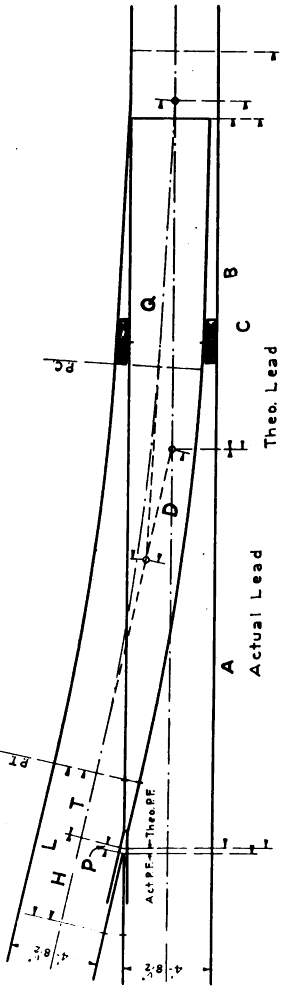
A yard or terminal is limited in its efficiency by the completeness of the interlocking system and to get the best results it is necessary to consider this very important item in every stage of the work. One of the set rules required continuous track circuits throughout with dead sections not to exceed 5 ft. in length

The diamond crossings and end frogs of slips where it was necessary to provide the short guard rail were the most difficult to insulate and required the development of four special types of joints. Type "A," which insulated the frog ends where the short guard rail is used. Type

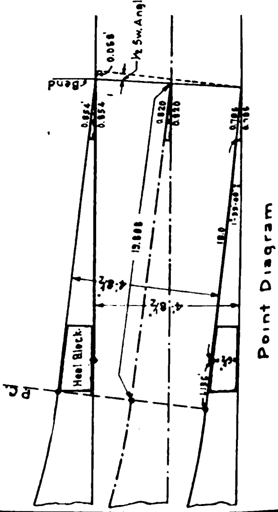
"B" where the filler block only is used and common to other frogs. Type "C" where the running rail and guard rail in diamond crossings are insulated, and Type "D" where the stock rail is attached to the solid manganese end of the crossing frog.

The special features of these insulated joints are the angle bars which are of the continuous type and made to extend the entire width of the base of rail instead of half the width as used in the standard joints. These joints have stood up exceedingly well, with practically no renewals of fibre since installed in August 1923.

The trackwork was in service for some time before the insulated joints were installed. Provision was made for this by having the fillers at frogs and crossings where the insulated joints were to be placed, planed ⅛ in. and steel shims installed instead of the fibre and ⅜-in. steel end posts placed between the rail ends



Frog No.	Angle	Theo. Lead	Theo. Rad	Act. Lead	Act. Rad	Act. Tan	A	B	C	D	Q	P	H (For 130# Rail)	T (For 130# Rail)	L (For 130# Rail)	H (For 100# Rail)	T (For 100# Rail)	L (For 100# Rail)	Frog No.
7	8°-10-16	65.918	461.431	63.500	333.752	19.007	32.959	30.249	31.069	7.890	38.895	0.292	6.292	3.708	10.000	7.792	5.208	13.000	7
8	7°-09-10	75.332	602.648	70.000	471.020	22.627	37.666	32.001	32.821	9.872	42.634	0.333	7.833	3.667	11.500	7.833	5.167	13.000	8
9	6°-21-35	84.750	762.734	75.000	602.061	24.747	42.375	32.250	33.070	11.618	44.635	0.375	8.375	3.625	12.000	8.875	5.125	14.000	9
10	5°-43-29	94.168	941.696	81.000	775.379	27.568	47.084	33.499	34.319	13.933	48.209	0.417	8.917	3.583	12.500	10.417	5.583	16.000	10
8 Short Lead	7°-09-10	75.332	602.648	61.250	470.749	22.614	37.666	23.251	24.071	7.240	31.268	0.333	7.833	5.167	13.000				Short Lead 8
9 Short Lead	6°-21-35	84.750	762.734	65.667	568.950	23.386	42.375	22.917	23.737	8.339	32.038	0.375	8.375	3.625	12.000				Short Lead 9



Point Diagram

CHICAGO UNION STATION CO.
CHICAGO, ILL.

TURNOUT DATA

Scale: June, 1920.
Office of the Chief Engineer.
No. 1327

to maintain the correct position of rails, which made it very easy later to replace with the fibre insulation.

The track circuits were laid out on ⅛-in. detail plans, all the insulated joints were definitely located, all connecting rails in the crossover system figured, with proper allowance for joints, and indicated on the special work with sufficient detail to enable the manufacturer to provide for them in the shop.

Competitive bids were taken for all the work. The first orders, due to many of the manufacturers not having experience with such heavy construction, showed quite a variation in prices. However, in the later orders their quotations were more uniform. All slips and crossings were fully assembled at the shops and carefully inspected. Units which were to be a part of a crossover system were held to a maximum variation in overall dimensions of ⅛ in. The points were fully bolted and thrown by hand for any possible binding, the plates were all assembled and properly fit for the planing and adjustable braces. All parts were plainly marked for reassembling in the field. The fact that this work was installed in some cases in isolated sections due to maintaining traffic through the proposed work, and later the gaps completed without any misfits, brings out fully the value of the co-ordinate system.

A complete series of theoretical staging plans was worked up before any actual construction work on the yard layout was begun, to determine from which side, the river or Canal Street, it was best to begin the work. The difficulty for either move was to get space for the first step in each yard. The Operating Department justly maintained it could not give up any existing tracks. However, with the removal of the Pennsylvania freight facilities, a limited space was provided on the river side. It was found for many reasons more desirable to begin the permanent work on the Canal Street side, and accordingly temporary facilities were provided on the river side by arranging some of the old freight tracks in the south yard for mail and express and laying temporary tracks in the north yard along the river, on space formerly used by the Pennsylvania Freight House.

This released space on the west side in which we were able to install four tracks

PLATFORMS

Items	Passenger	Baggage	Mail
Longest Platform (Loading) No. Yd.	1,318 ft.	1,201 ft.	
Longest Platform (Loading) So. Yd.	1,269 "	1,218 "	734 ft.
Shortest Platform (Loading) No. Yd.	841 "	730 "	
Shortest Platform (Loading) So. Yd.	672 "	751 "	252 "
Total lin. ft. North Yard	5,323 "	4,961 "	
Total lin. ft. South Yard	7,119 "	5,139 "	2,307 "
Total area (sq. ft.) North Yard	71,470	46,020	
Total area (sq. ft.) South Yard	97,720	53,180	29,805
Ramps—No.—North Yard	5	4	
Ramps—No.—South Yard	7	5	
Total lin. ft.—North Yard	330	756	
Total lin. ft.—South Yard	525	895	
Total area (sq. ft.) North Yard	5,000	7,970	
Total area (sq. ft.) South Yard	7,490	9,475	

Trainshed

North Yard		
	Area	132,470 sq. ft.
	Length	794 ft. 6 in.
	Width	177 ft. 4 in.
South Yard		
	Area	240,400 sq. ft.
	Length	935 ft. 3 in.
	Width	304 ft. 9 in. 267 ft. 8 in.
Length of covered platform, including viaducts and trainshed		
	North Yard	1,007 ft.
	South Yard	1,128 ft.

along Canal Street in the south yard and a temporary suburban station, relieved the congestion somewhat in the old station and at the same time gave much better facilities for the suburban traffic.

The Chicago & Alton freight terminal between Van Buren and Harrison Streets, and the Power Plant at Madison Street, prevented the staging to progress as we had planned and after the second stage it was necessary to work wherever space was available, which to the layman probably looked very chaotic. The staging of the work for both yards was complicated by the fact that the new track layout required also the rebuilding of viaducts and the street traffic was such that the city could not allow more than one river bridge closed at a time. We did maintain street traffic at Harrison and Polk Streets and pedestrian traffic at Madison Street at considerable expense for practically the entire construction of the new viaduct.

The staging plans were all worked up on large scale drawings, going into considerable detail, and gone into thoroughly with the operating department before starting the work. In many respects the staging plans were the most important plans prepared. In some stages of the work it was necessary to make repeated

STATISTICAL DATA RELATING TO TRACKWORK

Lineal Feet of Trackwork

South Approach, ladders and crossovers	130 lb. rail	23,345 ft.
South Station Tracks	100 " "	16,270 "
U. S. Mail Tracks	100 " "	4,370 "
North Station Tracks	100 " "	12,500 "
North Approach, ladders and crossovers	130 " "	13,525 "
South Joint Tracks	100 " "	8,470 "
P. F. W. & C. Neutral Tracks	100 " "	2,960 "
North Joint Tracks	100 " "	7,190 "
Total		88,630 ft.

SPLIT SWITCHES, FROGS, CROSSINGS AND SLIPS

		Approach and Station Tracks	Joint and Neutral Tracks	Total
Split Switches, 130 lb. rail		58	.....	58
Split Switches, 100 lb. rail		9	25	34
No. 6 Manganese Rail Bound Frogs,	100 lb.	1	1	2
No. 6 Manganese Rail Bound Frogs,	130 lb.	1	.....	1
No. 7 Manganese Rail Bound Frogs,	100 lb.	5	1	6
No. 7 Manganese Rail Bound Frogs,	130 lb.	2	.....	2
No. 8 Manganese Rail Bound Frogs,	100 lb.	3	21	24
No. 8 Manganese Rail Bound Frogs,	130 lb.	110	.....	110
No. 9 Manganese Rail Bound Frogs,	100 lb.	.....	8	8
No. 9 Manganese Rail Bound Frogs,	130 lb.	36	.....	36
No. 10 Manganese Rail Bound Frogs,	100 lb.	.....	2	2
No. 10 Manganese Rail Bound Frogs,	130 lb.	1	.....	1
No. 12 Manganese Rail Bound Frogs,	130 lb.	1	.....	1
No. 3½ Crossings	100 lb.	.....	1	1
No. 4 Crossings	130 lb.	11	.....	11
No. 4½ Crossings	130 lb.	4	.....	4
No. 8 Double Slips	130 lb.	31	.....	31
No. 9 Double Slips	100 lb.	.....	3	3
No. 9 Double Slips	130 lb.	16	.....	16

AREA OF TRACK SLABS

South Approach and Ladder Tracks	134,000 sq. ft.
South Station and Mail Tracks	374,900 " "
North Approach and Ladder Tracks	81,300 " "
North Station Tracks	240,000 " "
Joint and Neutral Tracks	144,000 " "
Total	974,200 sq. ft.

studies before one was found to meet the requirements.

The critical stage was reached in 1923 when it was necessary to remove existing tracks without being able to take advantage of the new tracks. This condition had been foreseen in the early staging plans; it existed for a comparatively short time. Traffic was shifted from day to day at possibly some inconvenience to the public and during this time more trains were handled than at any other period of the work, with practically no delays to traffic.

This was only accomplished through the whole-hearted support of the operating people. They were put to great inconvenience in the handling of baggage, mail and express, but willingly considered it as their part in the improvement.

In conclusion I wish to state that the special features of the trackwork for the Union Station are the uniform simplicity of the entire layout, the flexibility for train movements, the extra heavy construction, the skilled workmanship either from a general view or a detailed inspection of the work, and the perfect co-ordination the trackwork forms with the other necessary units of the terminal.

Signals and Interlockers in the Chicago Union Station

By Thomas Holt,* M. W. S. E.

Presented October 12, 1925

Whoever has witnessed the orderly procession of trains through the maze of tracks in a modern terminal cannot help but marvel at the system of signals and safety devices that makes it possible. The Chicago Union Station contains two such systems, one of six approach tracks serving fourteen station tracks and the other of four approach tracks serving ten station tracks. These systems are fully described in this paper.—Editor.

THE arrangement of the track layout on the Chicago Union Station property divides the switches at each end of the station into two distinct groups, one group of switches being near the entrance to the trainsheds, the other group being near the entrance to the Chicago Union Station property where trains are received from the coach yards or deflected to the coach yards.

In the early studies made for the interlocking of this track arrangement four interlocking plants were considered, two for each end of the station. The towers in which interlocking machines were to be placed for the operation of switches and signals would have been located, one adjacent to the coach yard entrances, the other adjacent to the trainshed tracks. This arrangement from the standpoint of interlocking the functions to be controlled, was very desirable but from the standpoint of operation and facilitation of train movement between the coach yards and station without interruption to the regular in and out-bound trains was not as desirable, due to the amount of intercommunication between the two towers properly to co-ordinate these train movements.

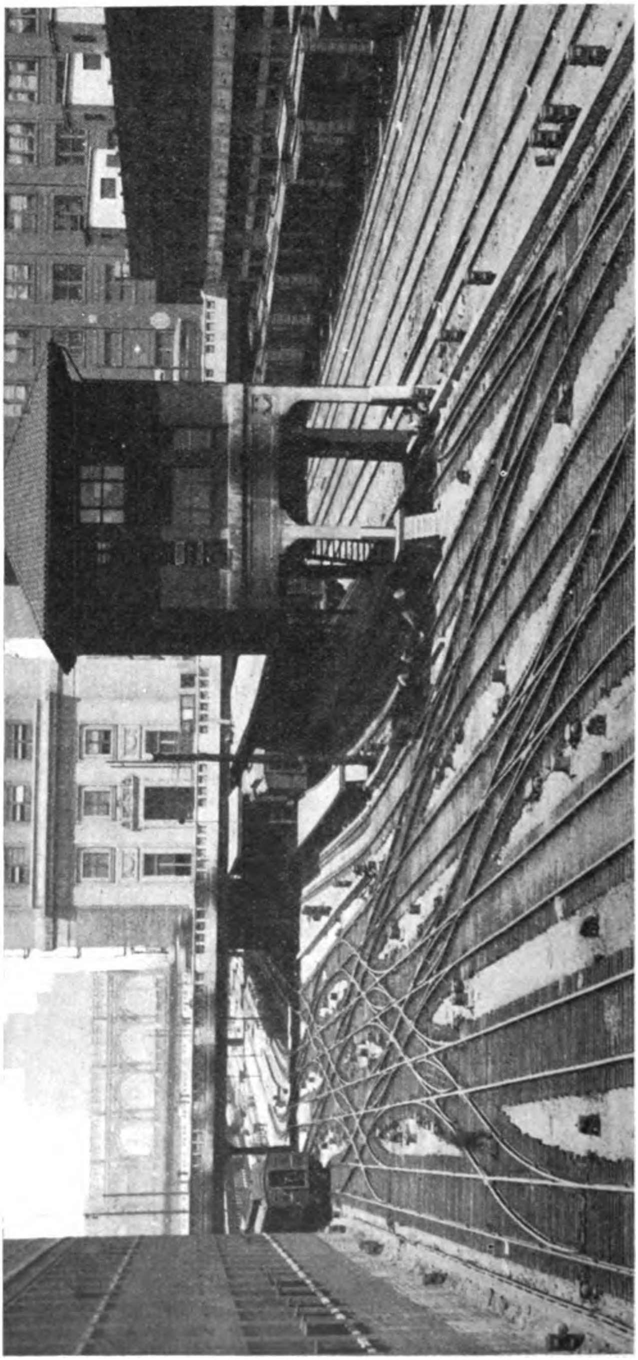
Careful consideration of the operating features led to the adoption of one central point at each end of the station for the control of all switches and signals.

The interlocking plant controlling train movements at the south end of the station operates 36 high signals, 70 dwarf signals, 38 movable-point frogs, 76 double slip ends and 42 single switches, operating 10.14 miles of track covering a territory 4800 feet in length.

The interlocking plant controlling train movements at the north end of the station operates 2 high signals, 57 dwarf signals, 15 movable-point frogs, 30 double slip ends and 41 single switches, operating 5.56 miles of track and covering a length of 3200 feet.

The interlocking machine in each tower has the appearance of one machine but in reality it is two distinct machines with two sets of mechanical locking for each

* Signal Engineer, Chicago Union Station Co.



THE SOUTH SIGNAL TOWER IS LOCATED AT THE THROAT OF THE STATION TRACKS. VIEW LOOKING NORTH TOWARD HARRISON STREET.

group of switches and signals controlled by it.

This arrangement of mechanical locking was found to be of great advantage during the installation of the interlocking system as the construction of tracks at the station ends was considerably in advance of the construction of tracks at the coach yard ends, and we were able to assume control of all switches and signals on the station ends when the permanent tracks were completed at these points. This had the appearance of placing in service one-half of an interlocking plant but in reality a complete interlocking plant was operating.

Power Distribution Systems

Electric power is supplied by the Commonwealth Edison Company at a pressure of 12,000 volts. This power can be applied either from the substation at the Headhouse or at the Mail Terminal Building. The current is brought to these substations over three independent cables to insure continuity of service. The voltage is stepped down to 2,300 volts single phase through duplicate transformers and distributed over the interlocking system. Two power lines are used in this distribution, each line having its own transformers at convenient points where the voltage is stepped down to 110 volts for serving the interlocking system. Power is normally on both of these lines but only one set of secondaries feeds the 110 volts to the interlocking system. An automatic transfer equipment is installed at each transformer location which will instantly cut in the secondary of the other line to serve the interlocking should power fail on the normal feed. The 110-volt busses which serve the interlocking system are sectionalized so that the normal feed from each transformer is in one direction only, but by closing a switch on the transfer equipment panel, each transformer will feed in both directions. This arrangement makes it possible to operate the interlocking system with both transformers at one location out of service by simply arranging the switches on either side of this location so the adjacent transformers serve this territory. This 110-volt current lights the interlocking towers, feeds motor generator sets in towers, lights all signals, feeds all track circuits, lights the illuminated track diagram and lever lights and is used for all signal indications and check locking between towers.

Compressed air for the operation of switches is furnished from two steam-driven air compressors located in the Chicago Union Station Company's heating plant. These compressors furnish the compressed air for the many various uses in and about the station in addition to serving the interlocking system.

The air is delivered to the interlocking system at 70 lb. pressure, after being run through a water after-cooler which reduces the temperature to 60 degrees, and before being fed to the main air line is passed through an air-cooled condenser located outside the building. The main air lines for serving the interlocking system are of 2-in. wrought iron pipe, one pipeline running continuously on each side of the track layout the entire length of the interlocking system with cross leads between the two sides at the proper points to insure air pressure to all functions should a break occur at any point in either main line.

Interlocking Towers and Machines

The interlocking towers are fireproof, consisting of reinforced concrete and steel construction with brick facing and tile roof. Floors are all of concrete with built-in chases for wires. The towers are of two stories with the relays, motor generator and storage batteries on the first floor. In the top floor is located a Union Switch & Signal Co's Model 14 electro-pneumatic type, interlocking machine, equipped with lever lights which are used for providing a visual indication as the condition of the section locking for switches and the position of signals. No light on a switch lever indicates that the lever is locked, while a light on a switch lever indicates that it is free to be moved. No light on a signal lever indicates that the lever and signal are in corresponding positions and a light on a signal indicates the lever reversed with the signal in normal position. The switch lever light has been found of great advantage in preventing excessive strains on the electric lever locks as the tower operators do not attempt to operate a switch lever unless the light is burning. The signal lever lights have helped in train operation giving the tower operator instant information

as to the operation of signal and the acceptance of a signal by a train. The lights on switch levers are green and the lights on signal levers red.

Illuminated Track Models

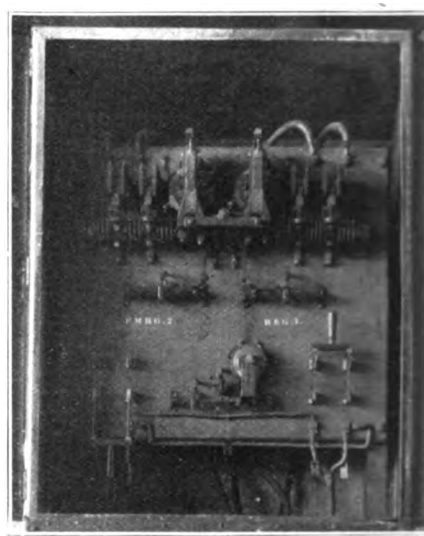
The track models are of metallic structure throughout and consist of a front plate 1/8 in. thick mounted on an angle iron frame so as to form a shallow box while the rear plate consists of removable doors for access to the interior. Luminous spotlight indicators are mounted in the rear of the front plate.

Tracks are indicated by a double line diagram of white lines on a flat black background to indicate the rails and all signals, switches, slips, movable point frogs and other features of the signaling system are shown in white. The scope of each track circuit is shown by filling in, between the white lines indicating the rails, with a distinctive color. The colors of adjacent track circuits are sufficiently distinct to differentiate clearly between them. The length of a track circuit is shown by the length of its particular color. The spot lights are placed as nearly as possible in the middle of each track circuit and show a green light when the track circuit is clear and no light when the track circuit is occupied. The lights for traffic direction also show an arrow pointing to the direction in which traffic is set up.

The south plant track model has 194 spotlights for track circuits, 2 for traffic direction between plants and 28 for train starting, a total of 224 spot lights. The north plant track model has 87 spot lights for track circuits, 2 for traffic direction lights between plants and 20 for train starting, a total of 109 spot lights.

Tower Relay Cabinets

Tower relay cabinets are made of steel with glass doors. They are of the multiple unit type and placed back to back at right angles to the interlocking machine but on the floor below. This is rather an unusual arrangement of tower relay cabinets; the usual arrangement being longitudinal or in the same direction as the interlocking machine. The great number of tower relays required to operate this interlocking system was further increased because of insufficient room along the tracks to house properly the track relays and forced all of these relays to be placed in the tower also. This necessitated economical use of space in the relay room on the first floor. By arranging the cabinets at right angles to the longitudinal axis of the interlocking machine each row of cases crossed the slot in the upper floor making access for wires between relays and machine easy and at the same time using the floor space to its maximum capacity. A longitudinal ar-



AUTOMATIC TRANSFER EQUIPMENT FOR SIGNAL POWER SUPPLY.

rangement of relay cabinets would give access to the slot beneath the interlocking machine for but two rows of relay cabinets, unless an elaborate system of chases connecting to this slot at right angles was provided in the top floor.

This slot in the top floor runs the full length of the interlocking machine and is covered by frame of same. The relay cabinets are arranged in double tier having six cases per tier with a space of 3 ft 4 in. between rows of cases, making an aisle from which 24 cases are accessible. There are 144 cases in the south tower, housing 674 relays, and 96 cases in the north tower, housing 342 relays.

Terminal Cabinets

All wires coming into the interlocking tower are connected to terminals in a terminal cabinet. This cabinet is built

of No. 16 gauge cold rolled furniture steel all parts of sections being riveted and welded together, properly reinforced and rigidly constructed. The doors have vault handles with a locking device. Strips of ebony asbestos transite board 1 in. x 6 in. x 8 ft. are mounted 8 in. from the back of this cabinet running vertically, to which all wires are attached on A. R. A. terminal posts, connection is made between this terminal cabinet and the relay cabinets through wire chases in the top floor.

Battery and Charging Equipment

Switchboard, motor generators and storage batteries are all housed in the same room. The storage batteries consist of 2 sets of 500 ampere-hour-capacity, ironclad Exide cells assembled in sets of 3 and 4 giving a pressure of 14 volts. These are mounted on a concrete platform 6 in. above the floor.

The storage batteries are used for the control of switch valve magnets, switch indication magnets, signal control relays, and route locking relays. The motor generator and switchboards are of the General Electric Co's make with one motor generator for each set of batteries.

Switch Movements

Switch movements are Union Switch & Signal Company's electro-pneumatic Type A-1, The cylinders for the operation of single switches are 5 in. in diameter, for slip ends 6 in. in diameter and for movable point frogs in connection with a slip end 7 in. in diameter. All cylinders have a 12-in. stroke. All of these movements are equipped with Union Switch & Signal Co's separately mounted Style C cut-off type valves which cut off all air pressure from the operating cylinders immediately after each operation thereby adding a safety feature and effecting a great economy in air consumption by avoiding air leaks due to loose-fitting pistons.

Signals

Signals are of the position light type. The high signals have a special arrangement of lights which was developed to suit the requirements of the Chicago Union Station Company. The standard position light signal is circular in construction consisting of 9 lights, 8 lights spaced equidistant on the circumference of a circle 18 inches from the ninth light which is the center of the circle. The lights on the circumference are so spaced that vertical, horizontal and 45° diagonal rows of three lights are formed, giving the signal indications by the position designated by the row of lights illuminated. The horizontal row indicates stop, 45° diagonal indicates caution, and the vertical row indicates clear. To give more indications than these three, requires an additional signal placed below, giving indications in combination with the top arm in the horizontal position.

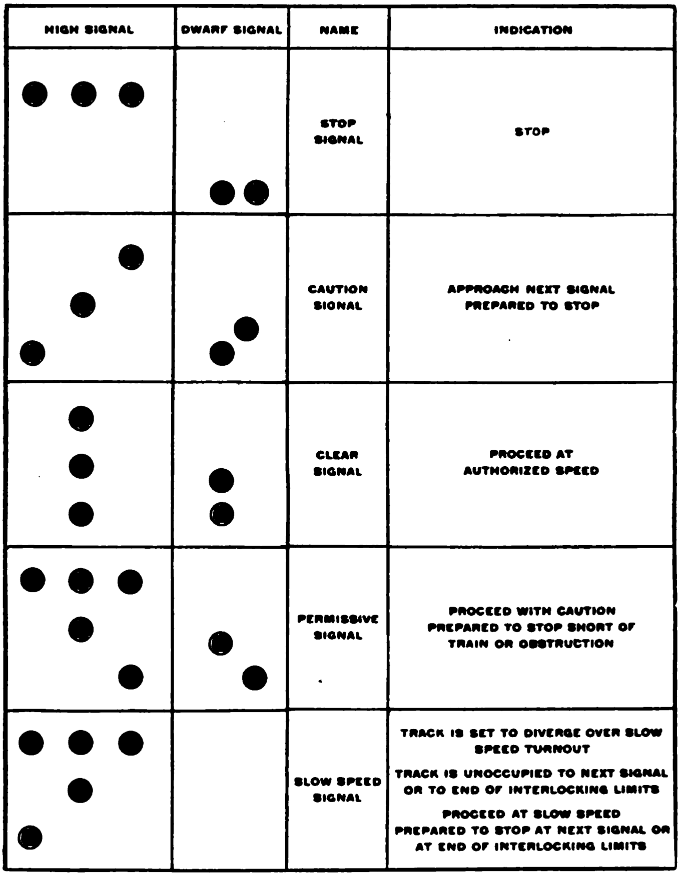
Five signal indications were required to operate trains properly in the terminal territory, namely stop, permissive, slow speed turn out, caution and clear. To have given these five indications with standard semaphore signal required three semaphore arms making a signal 24 feet in height. To have used a standard colored light signal would have required three separate units making a signal 21 feet in height. To have used the standard position light signal required 2 units maka signal 11 feet in height.

High signals were required to be attached to street viaducts which cross the tracks approximately every 800 feet. Special pains had been taken to give these street viaducts an attractive design and a very careful study was made to develop a signal which would give five indications and be small enough to be attached to the viaducts without obliterating the view of these attractive structures. This resulted in the development of a high position light signal which consists of two horizontal rows of three lights each with a single light placed in the center and half way between the two horizontal rows, a total of seven lights. This signal is 4 ft. 2 in. square and was readily applied to the viaducts.

The five indications given are as follows:

Top row of horizontal lights lighted indicate stop. The top row lighted in combination with the two diagonal lights to the right indicate permissive. The top row lighted in combination with the two diagonal lights to the left indicates slow speed. The three diagonal lights in the upper quadrant indicates caution. The three vertical lights indicates clear.

Dwarf signals are the standard position light dwarf consisting of four lights and



INDICATIONS SHOWN BY THE POSITION LIGHT SIGNALS.

giving four indications; stop, permissive, caution and clear. The addition of the fourth indication is a new development in signaling which makes the dwarf signal particularly suited for signaling a busy terminal to allow trains to occupy tracks to full capacity, and give complete information for the governing of traffic in terminal territory. The dwarf signal at clear indicates that the next signal is at clear or caution. The dwarf signal at caution indicates that the next signal is at stop but the track is unoccupied to the next signal. The dwarf signal at permissive indicates that the track immediately ahead is occupied and that train movement should be made with caution prepared to stop short of a train or obstruction. The dwarf signal at stop indicates that the route is not set. Use is made of the permissive indication in governing train movements to stub end mail tracks and the coal tracks at the heating plant. This arrangement ties up the dwarf signals into a complete signaling system with each dwarf signal having a distant indication giving the engine man advance information of the indication he may expect to receive on the next signal ahead. This allows train movement to be made at the maximum speed allowed in the terminal territory when the tracks ahead are clear and at the same time provides advance information for the restriction of speed when close follow-up movements are made.

Master Release

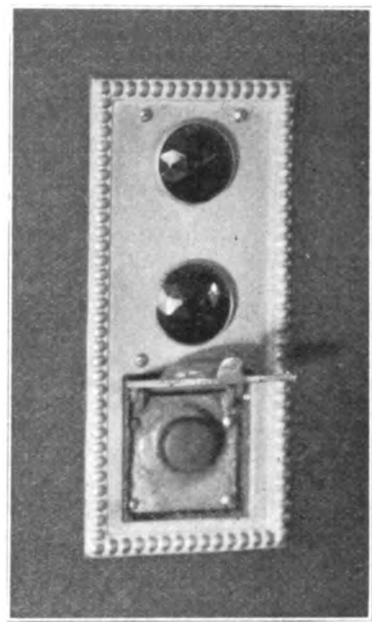
The connecting up of dwarf signals into a signal system with each signal

having a distant indication made it necessary to provide time releases for all dwarf signals for the introduction of a time period which must elapse between the time of changing a signal to stop, which has been cleared for a train, and not accepted by train, and the time the route can be changed ahead of signal. This meant that all signals in the interlocking system must be provided with time releases. There are 105 signals in the south plant and 63 in the north plant. Tower space readily accessible to tower operators for mounting the number of time releases required to release all these signals, presented a difficult problem.

Consideration was given to a type of time release which could be attached to each signal lever and be operated each time the lever was pulled introducing the time element when the lever was restored to normal. This required a specially arranged circuit to release an accepted signal without waiting for the operation of the time element. This type of time release would have been readily applied to the inter-locking machine and solved the problem of accessible space for mounting time releases, but the time element would be forced to operate each time the lever was pulled, and after consideration of the number of operations required of these levers each day it seemed unreasonable to expect a mechanical device of this type to stand this unnecessary service. An attempt was then made to design a time release which could be attached to the interlocking machine and be operated only when an unaccepted signal had been taken away. This led to the development of what we call a master time release.

This release is attached to a lever in the interlocking machine and is of the mercury type. The operation of the lever forces mercury out of a cylinder in which the mercury has been supporting a floating piston which closed the circuit for releasing the lever lock. The mercury flows back into the cylinder by the action of gravity as soon as the lever is moved toward normal and by adjustment of the openings for the return of the mercury the proper time element is introduced.

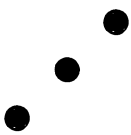
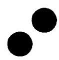
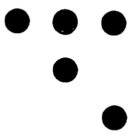
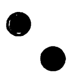
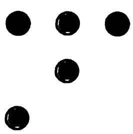
The circuits are arranged so that the operation of this lever will release any unaccepted signal which has been taken away and hence the name master release. All signal lock circuits are cut through this lever in its normal position and a special pick-up circuit for each lock release relay is cut through this lever in its reverse position. The release of the signal lever depends upon the lock release relay being energized and the release lever being normal. The reversing of the master release lever puts energy on the lock release relay which will then remain energized from energy on the signal lock circuit which is closed through one of



PUSH BUTTON AND COLOR SIGNAL LIGHTS INSTALLED AT EACH GATE.

the relay points just picked up. The master release lever is then moved toward the normal and encounters the operation of the time element which restricts the closing of the normal lever contacts until the time period has elapsed.

The instant releasing of accepted signals is not affected in any way by the operation of the master release lever, as a multiple circuit is arranged around the normal contacts of the master release lever through the back contact of the slotting stick and permissive stick relays which are dropped automatically as soon as the train accepts the signal.

HIGH SIGNAL	DWARF SIGNAL	NAME	INDICATION
		STOP SIGNAL	STOP
		CAUTION SIGNAL	APPROACH NEXT SIGNAL PREPARED TO STOP
		CLEAR SIGNAL	PROCEED AT AUTHORIZED SPEED
		PERMISSIVE SIGNAL	PROCEED WITH CAUTION PREPARED TO STOP SHORT OF TRAIN OR OBSTRUCTION
		SLOW SPEED SIGNAL	TRACK IS SET TO DIVERGE OVER SLOW SPEED TURNOUT TRACK IS UNOCCUPIED TO NEXT SIGNAL OR TO END OF INTERLOCKING LIMITS PROCEED AT SLOW SPEED PREPARED TO STOP AT NEXT SIGNAL OR AT END OF INTERLOCKING LIMITS

INDICATIONS SHOWN BY THE POSITION LIGHT SIGNALS.

giving four indications; stop, permissive, caution and clear. The addition of the fourth indication is a new development in signaling which makes the dwarf signal particularly suited for signaling a busy terminal to allow trains to occupy tracks to full capacity, and give complete information for the governing of traffic in terminal territory. The dwarf signal at clear indicates that the next signal is at clear or caution. The dwarf signal at caution indicates that the next signal is at stop but the track is unoccupied to the next signal. The dwarf signal at permissive indicates that the track immediately ahead is occupied and that train movement should be made with caution prepared to stop short of a train or obstruction. The dwarf signal at stop indicates that the route is not set. Use is made of the permissive indication in governing train movements to stub end mail tracks and the coal tracks at the heating plant. This arrangement ties up the dwarf signals into a complete signaling system with each dwarf signal having a distant indication giving the engine man advance information of the indication he may expect to receive on the next signal ahead. This allows train movement to be made at the maximum speed allowed in the terminal territory when the tracks ahead are clear and at the same time provides advance information for the restriction of speed when close follow-up movements are made.

Master Release

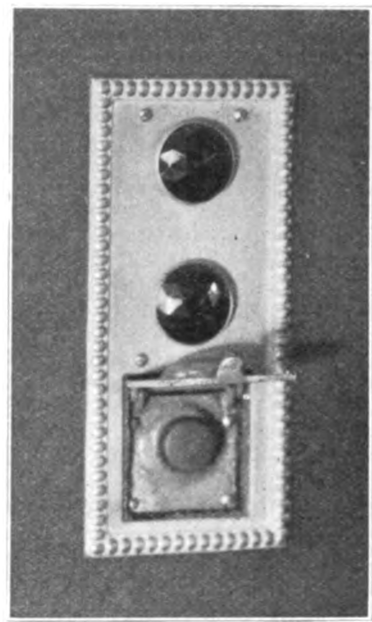
The connecting up of dwarf signals into a signal system with each signal

having a distant indication made it necessary to provide time releases for all dwarf signals for the introduction of a time period which must elapse between the time of changing a signal to stop, which has been cleared for a train, and not accepted by train, and the time the route can be changed ahead of signal. This meant that all signals in the interlocking system must be provided with time releases. There are 105 signals in the south plant and 63 in the north plant. Tower space readily accessible to tower operators for mounting the number of time releases required to release all these signals, presented a difficult problem.

Consideration was given to a type of time release which could be attached to each signal lever and be operated each time the lever was pulled introducing the time element when the lever was restored to normal. This required a specially arranged circuit to release an accepted signal without waiting for the operation of the time element. This type of time release would have been readily applied to the inter-locking machine and solved the problem of accessible space for mounting time releases, but the time element would be forced to operate each time the lever was pulled, and after consideration of the number of operations required of these levers each day it seemed unreasonable to expect a mechanical device of this type to stand this unnecessary service. An attempt was then made to design a time release which could be attached to the interlocking machine and be operated only when an unaccepted signal had been taken away. This led to the development of what we call a master time release.

This release is attached to a lever in the interlocking machine and is of the mercury type. The operation of the lever forces mercury out of a cylinder in which the mercury has been supporting a floating piston which closed the circuit for releasing the lever lock. The mercury flows back into the cylinder by the action of gravity as soon as the lever is moved toward normal and by adjustment of the openings for the return of the mercury the proper time element is introduced.

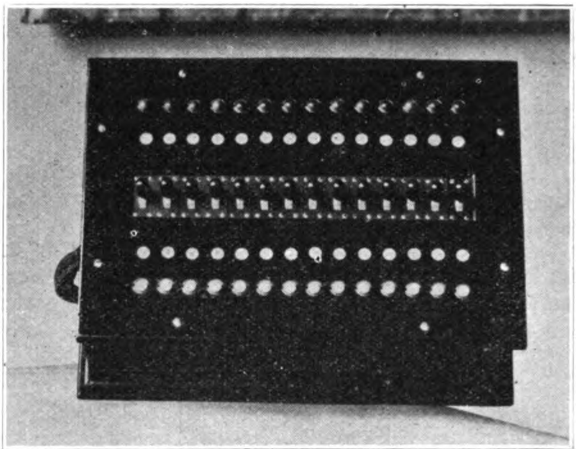
The circuits are arranged so that the operation of this lever will release any unaccepted signal which has been taken away and hence the name master release. All signal lock circuits are cut through this lever in its normal position and a special pick-up circuit for each lock release relay is cut through this lever in its reverse position. The release of the signal lever depends upon the lock release relay being energized and the release lever being normal. The reversing of the master release lever puts energy on the lock release relay which will then remain energized from energy on the signal lock circuit which is closed through one of



PUSH BUTTON AND COLOR SIGNAL LIGHTS INSTALLED AT EACH GATE.

the relay points just picked up. The master release lever is then moved toward the normal and encounters the operation of the time element which restricts the closing of the normal lever contacts until the time period has elapsed.

The instant releasing of accepted signals is not affected in any way by the operation of the master release lever, as a multiple circuit is arranged around the normal contacts of the master release lever through the back contact of the slotting stick and permissive stick relays which are dropped automatically as soon as the train accepts the signal.



TRAIN STARTING SIGNAL CABINET IN EACH TOWER.

The master release as finally adopted has two time elements, one of 12 seconds duration and one of 36 seconds duration. This is accomplished by attaching two mercury time releases to the same lever each having a different time period and arranging the circuits to select between these two time periods depending upon the particular indications which were given by the signal at the time it was taken away.

The selection of the time interval is entirely automatic. If a signal displays the permissive indication, the 12 seconds time only is affected but if a less restrictive indication is displayed, the 36 seconds time element governs.

Progressive Signals

The usual practice in operation of signals at interlocking plants is to retain the permissive indication when given, even if the conditions ahead change so that a less restrictive indication would be the proper one. This practice was brought about by two factors.

1st: In the use of semaphore arms the permissive indication is given by a bottom arm in combination with two top arms at stop. To give a less restrictive indication requires the bottom arm to go to stop and one of the upper arms clear. This makes it necessary to give a stop signal between the permissive and a less restrictive indication and as this change may occur just as the train is approaching the signal the engine man sees the signal go to stop and may make an emergency application of the brakes to avoid overrunning a stop signal before he discovers that the signal is changing to a less restrictive indication. On the other hand if the usual practice allowed the most restricted indication to be displayed while changing from a permissive to a less restricted indication, it might result in improper observance of the most restrictive indication.

2nd: The permissive indication is usually controlled by a straight power circuit without the semi-automatic feature which causes the signal to go to stop as soon as accepted by a train. This allows the signal to remain giving the permissive indication regardless of the number of trains which accept it unless the tower operator restores the lever to normal. This is considered good practice because the signal in advance of permissive indication indicates "approach the next signal prepared to stop," and the movement of the train would be under control should a tower operator overlook putting back the lever until the next train, which must take a different route, is approaching.

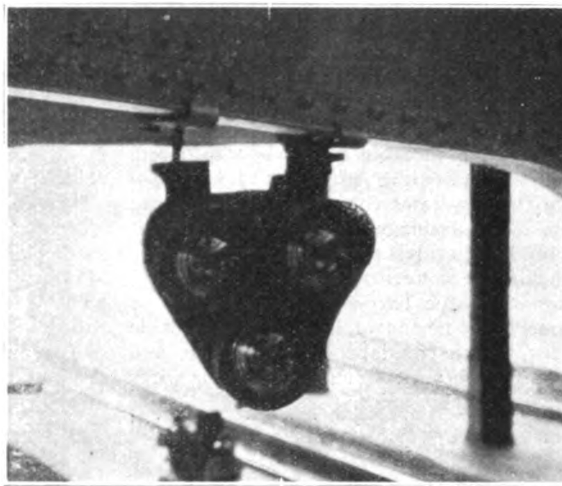
The almost instant change of indications on light signals together with giving all our signal indications on one unit removed the first objection.

The arrangement of our circuits so that all signals automatically assumed the stop position immediately upon being accepted by a train, regardless of the indication given, removed the second objection, hence we were able to make all our signal indications automatically progressive as the track cleared ahead.

This has been found of great benefit during the rush hours as trains at all times get the best possible indication the conditions warrant, and it has also quickened the tower operation as our layout covers so much territory that many trains take considerable portions of the same route and all that is necessary to give a signal for a train following another to the same route is to push the permissive button.

Circuits

Circuits for the operation of switches consist of wires between the interlocking machine and magnets on the switch movements which, when energized, admit compressed air to the piston in the switch cylinder causing the switch to move to correspond with the movement of the lever in the interlocking machine. The information that the switch has responded to the lever movement is conveyed to the tower operator by two wires operating a polarized relay at the tower.



TRAIN STARTING SIGNAL MOUNTED IN TRAIN SHED NEAR EACH TRACK.

This relay consists of two neutral magnets and one permanent magnet, the neutral magnets operating contacts which close whenever current is flowing in the magnet coils regardless of the direction, and polarized contacts which open or close depending upon the direction the current is flowing. The first movement of the switch lever applies battery on the switch magnets admitting compressed air to the switch pistons. As soon as the switch starts to move, battery is mechanically cut off the polarized relay thereby cutting power off the lever lock and holding the lever at a point a little beyond its middle position. The switch lever is held in this position until the switch has completed the movement and been securely locked. The movement of the switch mechanically reverses the direction of current on the polarized relay closing the neutral points and the polarized points, releasing the switch lever and allowing the complete movement of the lever to be made, which in turn releases the mechanical locking in the machines that prevented the movement of all signal levers governing train movements over this switch. The signal levers can then be operated and in turn mechanically lock the switch levers to prevent their operation. The wires controlling signals are cut through the contracts on the polarized relays so that the opening of a switch point by something dragging from a train or the movement of a switch from the ground independent of the lever will at once put and keep at stop all signals governing over it.

Route locking circuits are applied to all switches which electrically lock all switch levers of the route lined up immediately upon a train accepting the signal governing over this route. Sectional release circuits are applied to release all switches just as soon as the train has passed over them thereby keeping all switches free for use after being passed over. This allows a quick change of the line up for a following train and permits maximum use of all functions.

Wire, Cables and Duct Lines

The wires controlling operation of the interlocking system are made up in braided cables running from twin to 29-conductor. These cables are continuous from the terminal case in the interlocking tower to a terminal case located near the function to be controlled. From this point the wires are run in steel-taped cables to the function. These steel cables rest on a concrete slab and are covered with ballest. The concrete slab runs continuously under all switches throughout the entire layout with a minimum of 8 inches of ballast beneath the bottom of the switch ties.

Concrete trunking and capping are used extensively for housing these cables between the tower and cross leads to func-

tions. Where trunking could not be applied, fiber conduit encased in reinforced concrete was placed beneath the trackslab.

In the early studies the use of fiber conduit for all cable runs was considered, but the difficulties encountered in crossing the sewers at the streets and dodging the track drainage system and the great number of outlets required for cross leads due to the concentration of switches and signals at the two groups, caused us to consider a means of housing these cable runs, which could be on the surface and from which outlets could be had for wires at almost any point.

Trunking took care of the situation but it was felt that something more durable than the usual wood trunking should be used and so concrete trunking and capping were developed.

The concrete trunking is rectangular in section 8 in. in height and 9 in. width inside measurement. Each section is 8 ft. in length and weighs 350 lb. being supported at the ends by concrete piers.

Where outlets are desired the support for trunking is made large enough to form a foundation for a terminal case and an opening is provided in the side of the trunking at these points to allow the entrance of the cables from the tower. An opening is also provided in the trunking and terminal case support from the base of terminal case and underneath the trunking for outlet for the steel taped cables. The capping is made in 4 ft. lengths and weighs 75 lb. per length. Both trunking and capping have ¾-in. overlapping joints. The lap on the capping is arranged so that both ends on each length are lapped on the same side with the lap reversed on adjacent sections to allow the removal of the capping at any point in the line.

Track Circuits

Energy for operation of track circuits is applied to the rails through steel-taped cables which lie in the ballast. These cables are made up of 4 No. 9 A. W. G. copper wires which are brought in through the bottom of a concrete foundation which supports a pot head adjacent to the rails and made fast on standard American Railway Association terminals. Connection is made to the rails by short pieces of No. 6 A. W. G. copperweld wires, one end of which is fastened to the A. R. A. terminals and the other end attached to the rails with standard channel pins.

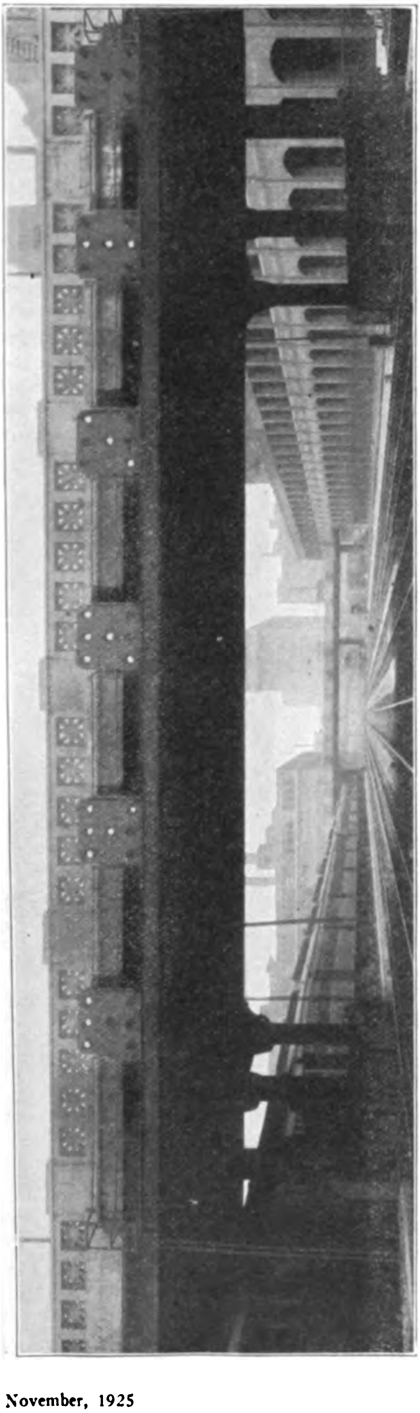
Alternating current is used on all track circuits at an average pressure of 4 volts. This current is supplied by track transformers which have one primary and four secondaries making it possible to feed four track circuits from one transformer. The secondaries also have taps which allow a variation of voltage from 3 to 17 volts and use is made of this in some cases to light signals from the track transformer.

Track circuits are continuous throughout the entire length of the interlocking system, no dead sections being greater than 5 feet in length. All track relays are located in the interlocking tower making necessary a booster transformer at the relay end, which raises the voltage to an average of 100 volts for transmission to the interlocking tower. There are 212 track relays housed in the south tower.

Train Starting System

The system of intercommunication between conductors, gatemen and interlocking operators employs three-indication, colored-light signals located adjacent to the station concourse, with one signal for each station track, two-indication spot-lights at the entrance gate for each track and two-indication spot-lights on the illuminated track model in the interlocking tower. Push button control switches are spaced approximately every 250 ft. on the train shed columns, in passenger platforms for the use of trainmen. The push buttons for gatemen are placed at the gates directly beneath the spot lights. The push buttons for tower operators are placed on the operator's desk in the interlocking tower. The operation of the train starting system is as follows:

First — The conductor pushes the button nearest to his location on the platform, lighting the red spot-light, on the illuminated track diagram in the interlocking tower, which is placed at the end of the track corresponding to the track from which the train is leaving and as the information is received at the tower the red light is lighted in the colored



POSITION LIGHT SIGNALS MOUNTED ON THE TAYLOR STREET VIADUCT.

light signal suspended in the train shed adjacent to the station concourse and beside the track from which the train is leaving.

Second -- If the tower operator is prepared to handle the train he pushes the button on the operator's desk, thus changing the colored light signal near the concourse to yellow, changing the light on the illuminated track diagram to yellow and lighting the yellow spot light at the gate.

Third — The gateman after closing the gate immediately pushes his button at the gate, changing the color light signal to green and the spot light at the gate to green thus permitting the train to leave, providing the proper indications of interlocking signals have been received.

Fourth — The train immediately upon accepting the first interlocking signal, automatically puts out all train starting lights.

Conclusion

In all our studies we had in mind quick, as well as safe operation of trains in the terminal.

Our track layout is complicated with current of traffic in both directions on all tracks. Trains are deflected over cross-overs and turn-outs arranged for a multiplicity of routes. It appeared that giving complete information to engine men of the conditions of tracks ahead by signal indication rather than by trusting them to determine these conditions for themselves would both quicken the train movement and make it safer. We assumed that a careful engineman if moving on a signal which just gave him permission to proceed and no further information, would do so with caution prepared to make a stop, watching the line up of switches to determine if he was about to be deflected to an occupied track and thus unnecessarily slow up train movement when the route was clear, while the less careful engine man would take a chance and move into the terminal territory at a speed which would make an emergency stop difficult, thereby making follow up movement hazardous unless the maximum speed allowed in the terminal was a very slow one.

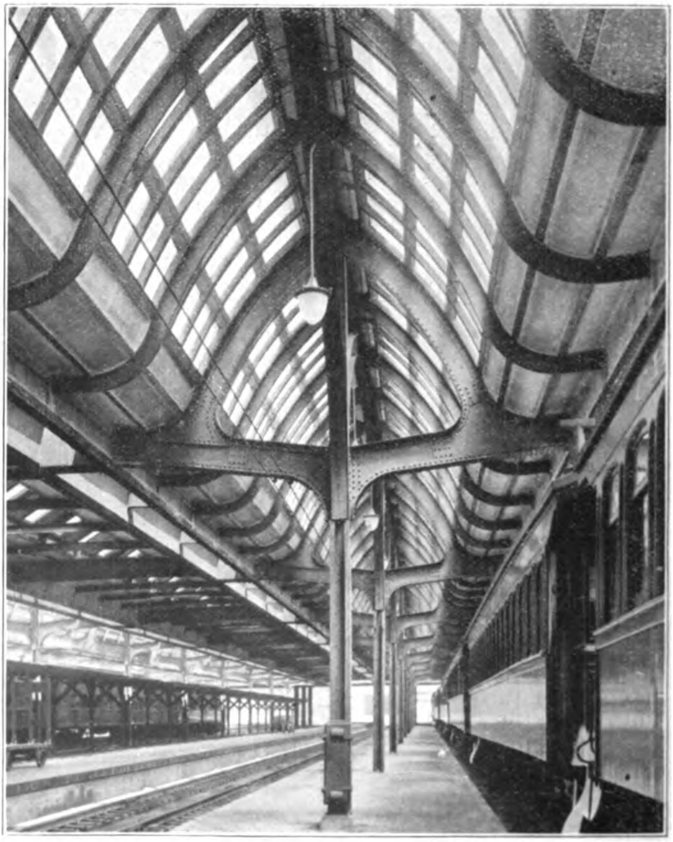
The addition of the fourth indication

en dwarf signals made it possible to have train movement at a speed which was the maximum speed at which cross-overs and turnouts could be taken with safety on all signal indications but the permissive, providing a proper alertness was used after passing a caution signal to approach the next signal prepared to stop. The permissive indication, which was preceeded by a caution signal, was the only signal requirig a very careful and slow movement and required the engine man to look out for himself.

We assumed that having the permissive indication would quicken all movements made on the other indications because these indications assumed the responsibility for the conditions head while the permissive indication plainly threw all responsibility of movement to the engine man and would slow up the movement to a point which made close follow up movements safe.

Practical operation of the interlocking system has proved our reasoning to be correct.

The Station end of the south interlocking plant was put in service March 1, 1924. The station end of the north interlocking plant went in service December 2, 1924. Improvement in train operation was experienced immediately after getting these plants operating. Observations of train movements together with reports coming from engine men, back-up men and supervising officials indicate that the complete information furnished by signals as to the conditions ahead is of great benefit in operating a busy terminal, and adds considerably to the speed of operation.



TECHNICAL PAPERS

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Some Features of the Structural Design of the Chicago Union Station

By E. WEIDEMANN,* M. W. S. E.

Presented September 28, 1925

Most important of all structural considerations in any project is that of the foundations which in the case of the Chicago Union Station presented unusual complication, because of a change in design, midway in the early construction, which required foundations for a skyscraper rather than a low building as at first contemplated. The soil at this place is so unstable, that it was necessary to lay concrete slabs to carry the railroad tracks. These slabs for the tracks and platforms cover an area of more than 25 acres. Structural features of the headhouse with its enormous waiting room, the beautiful concourse, train sheds of unusual design and viaducts over the station property are herein described by Mr. Weidemann, who was in charge of their design. —Editor.

Soil Conditions and Foundation Problems in General

An extensive survey of the soil condition within the station area, including nearly 100 test borings at various locations, disclosed that bed rock is found at an elevation varying between 115 feet and 55 feet below Chicago city datum, the rock surface gradually sloping upward in a southerly direction. Hardpan is found at an elevation of between —50 and —70 feet below city datum (generally around —55 to —60) in a layer of 6 to 20 feet in thickness and although this layer may occasionally extend down to the bedrock, it is usually separated from the rock by a layer of sand, sandy loam, blue clay mixed with gravel, boulders, sand, etc. and this layer is often waterbearing. Plastic blue clay is generally found to extend all the way down from the surface to hardpan, the first 30 to 40 feet being quite soft, but often getting stiffer as the hardpan stratum is approached. The first few feet of top soil, below the fill, is mostly blue and yellow clay and very soft. As the track subgrade has an elevation of between +4 and —4 the carrying capacity of the top clay was of considerable interest and several tests were made, which indicated that the capacity would vary between ½ ton to 1¼ ton per square foot of ground, depending upon the amount of water present near the test pit. Under a load of 2 tons the same soil would settle ⅝ to 1¾ inches. Generally at an elevation between city datum and —4 soft blue clay would be encountered that would be somewhat stiffer, but would not vary much in consistency for the next 30 to 40 feet in depth. It was quite evident that in the case of all heavy concentrated loads, unless pile foundations were provided foundations in the form of concrete caissons must be sunk below the soft clay strata to hardpan. In all some 1500 concrete cylinder pier foundations have been constructed for buildings and viaducts and included in the station project, and from time to time the carrying capacity of the hardpan has been tested. Hardpan, as referred to above, is a very hard, compact and comparatively dry and brittle clay containing a mixture of grit, gravel and pebbles and

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must be excavated by picks or be grubbed. An analysis of the hardpan under the test caissons at Adams Street and the River (as referred to later) gave the following results:

Gravel content (sifted through No. 10 sieve and washed) 13.8% by volume, consisting of limestone, trap rock, granite, flint and quartz.

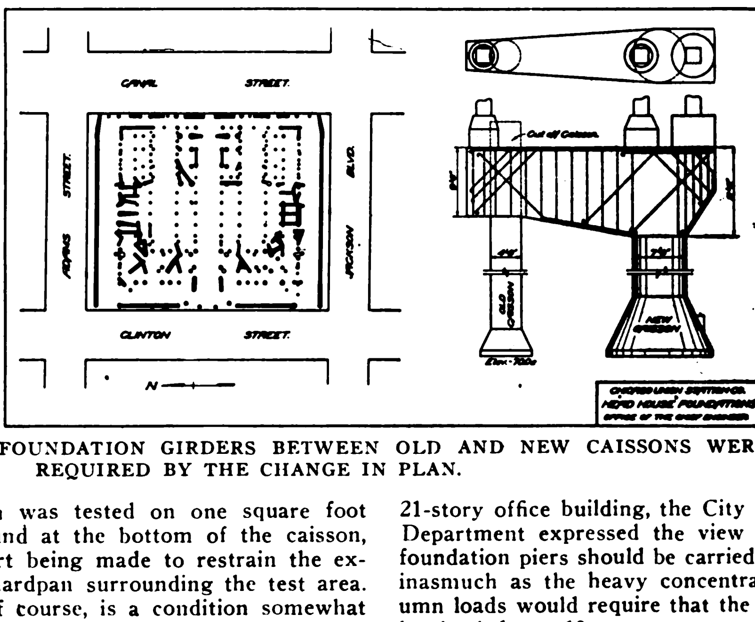
Powdered clay passing No. 50, 80, 100 and 200 mesh sieve was found to be 99.5%, 90%, 75.6% and 60%, respectively.

Water content was 11.5% to 12% by weight, which was somewhat moister than the hardpan ordinarily encountered.

Weight was 135 lb. per cubic foot.

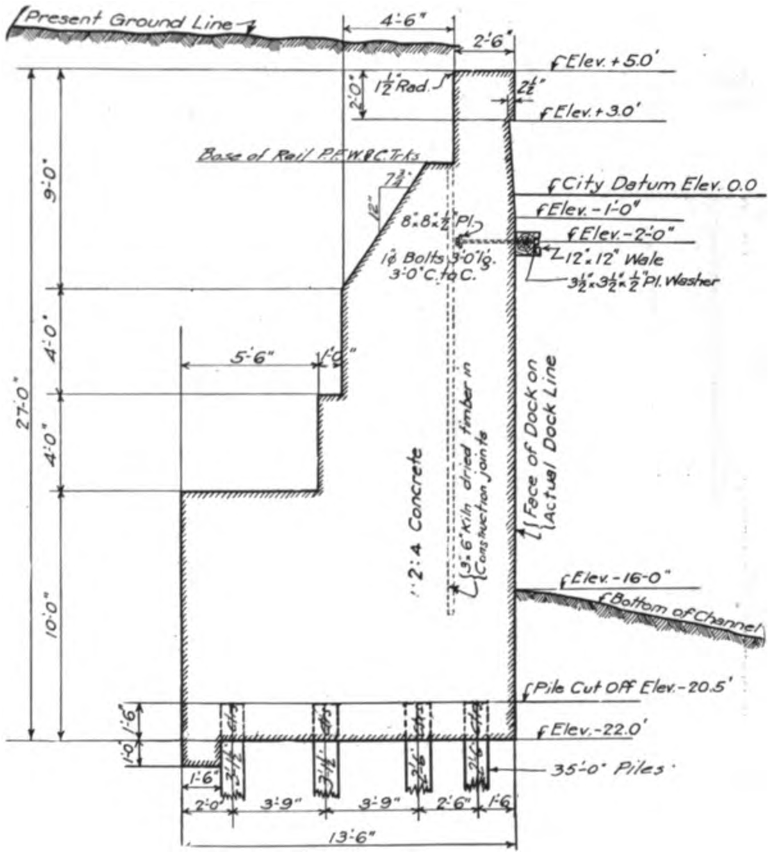
Frequently the carrying capacity of the under the same loading, an interesting illustration of the increase in carrying capacity of the soil as the depth below the surface of the ground increases.

As already stated the material found below the hardpan, between the hardpan and the rock, is frequently waterbearing, while the clay excavated above the hardpan is impervious to water, a fact which was of great importance as it permitted all the caissons to be sunk to hardpan in open excavation. In general, and for all viaduct foundations, the hardpan, of course, was considered amply sufficient to take care of the loads, but in the case of the Headhouse, after the conclusion had been reached to combine this with a



FOUNDATION GIRDERS BETWEEN OLD AND NEW CAISSONS WERE REQUIRED BY THE CHANGE IN PLAN.

hardpan was tested on one square foot of ground at the bottom of the caisson, no effort being made to restrain the exposed hardpan surrounding the test area. This, of course, is a condition somewhat different from and much less favorable than the actual case of a concrete caisson filling the entire excavation pit. Settlements ranging from 1/8 in. to 1/2 in. were observed at different locations under a load of 12 tons per square foot. In connection with the Headhouse foundation work a similar test was made on a 6-foot thick hardpan layer at elevation —65 and a settlement of 1/8 in was observed under a load of 12 tons per square foot. An additional test was made on the "Fine dry sandy loam" at an elevation —72 underlying the 6-foot stratum of hardpan and only 1/4 in. settlement was observed 21-story office building, the City Building Department expressed the view that the foundation piers should be carried to rock, inasmuch as the heavy concentrated column loads would require that the hardpan be loaded to 10 tons per square foot instead of a maximum of 6 tons as had been the general practice throughout the work formerly. Considering that test borings and actual experience in other locations had indicated that an excavation through the hardpan strata down to rock might involve the encountering of underground water with the accompanying great additional expense of caisson foundation work, and that it would involve the loss of caissons already in place, as it was not deemed good practice to combine rock foundations with foundations on clay, it was decided to prove by an



CROSS SECTION OF THE CONCRETE DOCK WALL BUILT ALONG THE RIVER BETWEEN MADISON ST. AND JACKSON BLVD.

actual caisson test to the satisfaction of the City Building Department that a loading of 10 tons per square foot on the hardpan was not excessive, but on the contrary conservative. These full sized caisson tests which were described by Mr. D'Esposito in the paper published in the Journal of the Western Society of Engineers of February, 1924, showed the following results:

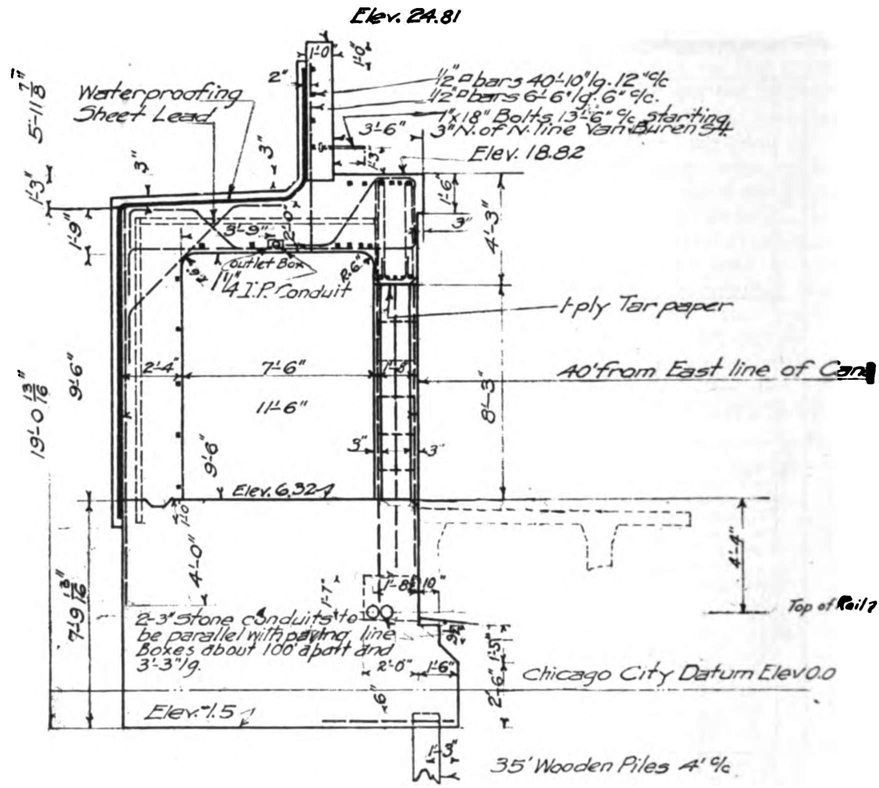
(a) A four-foot-diameter concrete cylinder pier with a belled base sunk to hardpan through about 70 feet of clay under loads of 8, 13.5 and 18.5 tons per square foot of the ground settled $\frac{3}{32}$ in., $\frac{7}{32}$ in. and $1\frac{1}{16}$ in., respectively. Upon removal of the load the pier recovered $\frac{3}{8}$ in.

(b) A straight four-foot-diameter concrete cylinder pier without a belled base sunk to hardpan through about 70 feet of clay under loads of 12.5, 28, 51 and 88 tons per square foot of the ground settled $\frac{1}{8}$ in., $\frac{5}{16}$ in., $1\frac{1}{8}$ in. and $2\frac{7}{32}$ in., respectively. Upon removal of the load the pier recovered $\frac{3}{8}$ in.

(c) Test of the friction developed by the straight cylinder pier without bell showed that pressures equivalent to 300 lb., 500 lb., and 600 lb., per square foot of exposed surface of caisson (lagging was not removed) caused settlements of 0, $\frac{1}{8}$ in., and $\frac{1}{4}$ in., respectively. A pressure equivalent to 700 lb. per sq. ft. of exposed caisson was required to develop the maximum resistance to sliding.

Retaining Walls

Among the retaining walls constructed, two in particular were of importance. Along the east side of the station prop-



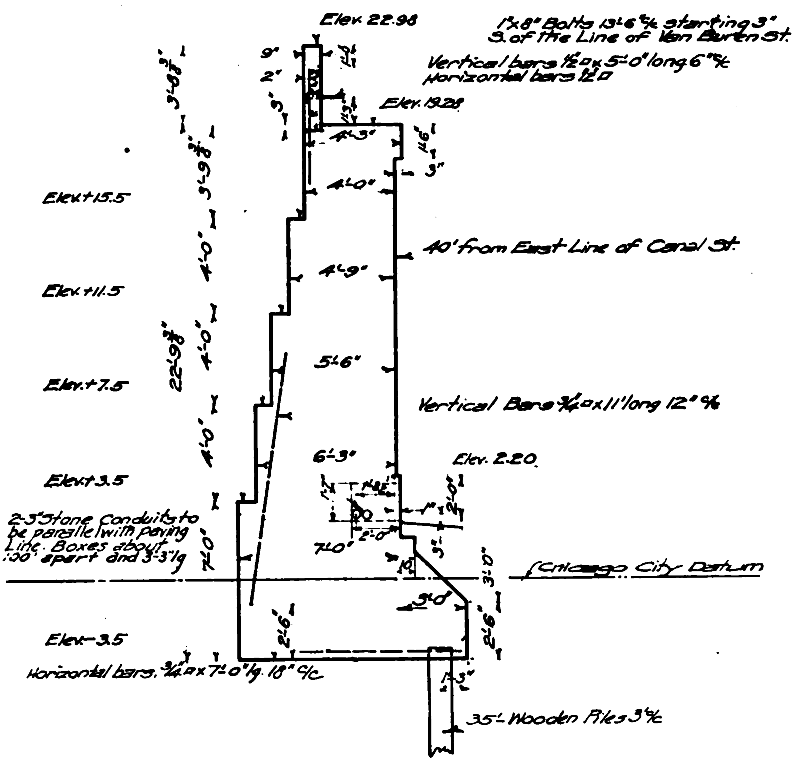
CROSS SECTION OF RETAINING WALL ALONG CANAL ST. WHICH ALSO INCLUDES THE PASSAGEWAY FROM THE CONCOURSE TO THE ELEVATED RAILWAY STATION.

erty, on the river front, between Madison and Jackson Boulevard, a concrete dock wall was constructed of a length about 1350 ft. The wall is of the gravity type, 27 ft. high, with a base 13 ft. wide, and is supported on four rows of piles spaced 3 ft. 6 in. centers. The base of the wall is carried down to elevation —22, which is the bottom of the river channel and the top is extended to elevation plus 5, or a couple of feet above track elevation. The wall was constructed with transverse joints about 40 ft. center to center, and the joints were waterproofed with a 3x6-in. kiln dried timber concreted in with the wall sections. In designing the gravity section, water pressure was assumed to act under and back of the wall and the loading of wooden piles was limited to about 18 tons.

Along the west side of the station property, along Canal Street, a concrete retaining wall was constructed between Harrison Street and Washington Street. also of the gravity type, about 2700 feet in length and of an average height of about 23 feet. Usually the track construction adjacent to the face of the wall limited the toe projection and one row of 35-foot wooden piles spaced 3 ft. center to center was used. In locations where a large toe projection was permissible, piles were omitted and the pressure on the soil limited to about 1.5 tons per sq. ft. The passageway leading from the concourse underneath Canal Street at Jackson Boulevard south to the Metropolitan Elevated Railway Station, 7 ft. 6 in. wide and 270 ft. long was constructed in the wall and as a part of it by changing to a reinforced concrete section.

Track Slabs and Platforms

The soft and wet clay which was encountered throughout the station site led to the conclusion that maintenance con-



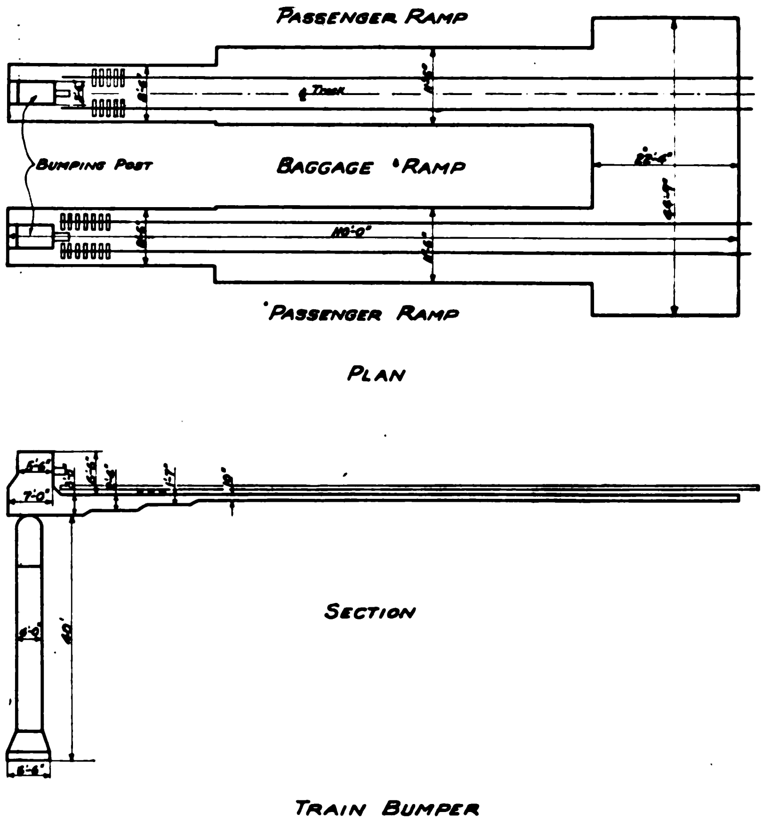
TYPICAL SECTION CANAL ST. RETAINING WALL.

sideration would justify covering practically the entire station yard with a concrete slab. It was also under all special track work in the approach yard and under the major portion of the approach tracks and covers in all more than 25 acres.

As the station track construction presents an exposed concrete surface with the ties laid directly on the concrete, it was of importance that the track slab should be so constructed that no cracks would develop. For this reason, the slab was constructed in sections, each track being carried on a strip generally 14 ft. wide and with joints spaced 21 ft. to 30 ft. apart. The slab which is 10 in. thick of about 1:2:4 mixture, is steel reinforced at top and bottom in both directions to take the bending stresses on the assumption of a uniformly distributed engine load on the soil of not more than 1000 lb. per sq. ft., which is about the loading, indicated by tests, that can be conservatively carried without undue settlement. Joints were made by pouring every alternate section and using ¾-in. elastic joint filler. The remaining area between the track slabs, underneath the platforms, was covered with a 10-in. layer of plain concrete.

The concrete slab under the approach tracks, which have ballasted track construction, is not reinforced for bending stresses, but has heavy wire mesh or a double layer of light rods placed at the center of the 10-in slab to prevent separation, if cracks develop.

Both baggage and passenger platform slabs are laid on a compact fill of screenings retained by small concrete curbwalls resting on the track slabs, the screening fill being used in preference to spanning the curbwalls with a reinforced concrete slab as a matter of economy. Contact between curbwalls and platform slabs is prevented by a 1-in. opening. The baggage platform slab has a 1-in. cement mortar or concrete asphalt finish and has steel plate guards on the sides projecting 2



THE BUMPING POSTS ARE CONNECTED TO THE TRACK SLABS AND REST ON A CAISSON-TYPE FOUNDATION.

in. above the slab. The passenger platform slab has a troweled concrete finish only. Both slabs, which are of about 1:2:4 mixture, and provided with light steel reinforcement at the top to take care of temperature stresses, are laid in sections about 40 ft. long, separated with an elastic joint filler. A detailed description of the work by Mr. D'Esposito is published in "Railway Engineering and Maintenance" for September, 1923.

Bumping Posts

Bumping posts have been provided at the end of all tracks in the form of a block of concrete 3 ft. 6 in. wide, 7 ft. long and 5 ft. 3 in. high, provided with Westinghouse draft gears at the height of the car coupling to permit of a give of about 2½ inches. The heavily reinforced concrete block is anchored to the concrete track slab which has been provided with the necessary extra longitudinal steel reinforcement and has been extended back without joints for a length of about 100 feet and then made to overlap the adjacent platform and baggage platform slabs on either side to obtain the required resistance against sliding. The overturning moment has been taken care of by increasing the resistance of the track slab to bending, as required, and by supporting the concrete bumper on a caisson, as the baggage ramp construction prevented the use of a spread base of sufficient dimensions.

The bumpers have already proven their efficiency and have withstood shocks great enough to demolish a Pullman car.

Trucking Subway

A subway which serves both for trucking and as a pipe tunnel connects the Power House with the Mail Building and

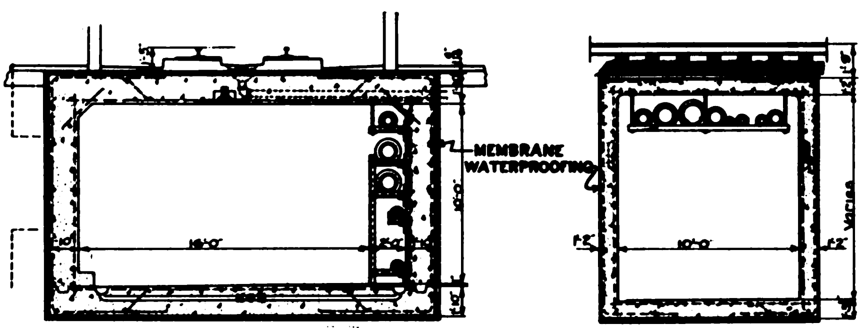
extends from the Mail Building, along the River front, 580 feet to the basement of the concourse. The subway, which carries a track immediately on top of the concrete roof, is 18 feet wide and 10 feet high and has been designed and constructed as a monolithic box of reinforced concrete with a slab thickness throughout of 1 ft. 10 in. It has a membrane waterproofing protected with 2 in. of concrete.

The subway was designed to span the 40-foot street car tunnel at Van Buren Street as a reinforced concrete girder, transmitting the load to the tunnel sidewalls.

Viaducts

The new street elevations over the station property, as established by the City ordinance, were naturally worked out with a view of obtaining as low elevations and possible. The column bents for the viaducts within the station track zone are generally located at the center line of passenger platforms and the span lengths are about 45 ft. In the approach yard the spans across the six station tracks are about 83 feet.

The ordinance stipulated that the viaducts be designed in conformity with specifications issued by the Department of Public Works governing the reconstruction of viaducts and that the type of construction be subject to the approval of the Commissioner of Public Works. It provided also that no foundations within the street width should be carried down below elevation —15 or provision must be made for the construction of future subways. With reference to the architectural features of the structures, it

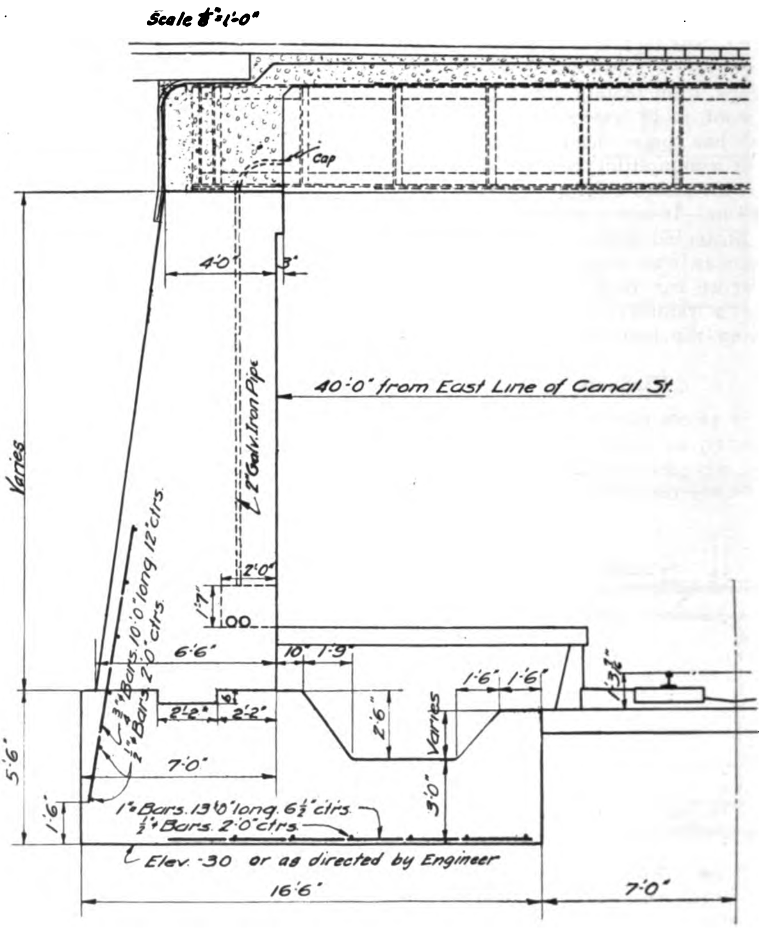


TYPICAL SECTION A-A

TYPICAL SECTIONS OF TRUCKING SUBWAYS—LEFT, BETWEEN CONCOURSE AND MAIL BUILDING—RIGHT, MAIL BUILDING TO POWER HOUSE.

easy gradients as possible, both in the interest of traffic consideration and property damages. Canal Street, which had formerly a very undulating profile, was straightened with easy grades and nearly all the east and west streets were carried practically level across the station property and restricted to short runoffs with a maximum grade of 3% at the approach to Canal Street. As the established street grades and a locomotive clearance requirement of 17 ft. 2 in. called for a great amount of excavation of the entire station site and at a certain location (in the vicinity of Madison Street) would bring the tracks below river level, it is evident that the depth of floor construction allowed for the viaducts in many instances was made as small as thought practically was agreed by the Railway Companies that the plans should be satisfactory to the City Plan Commission, also that wherever physically possible to do so the viaducts should be designed without girders or trusses projecting above the street surface. With the expection of Lake and Randolph Streets, where conditions made it impossible, this understanding has been strictly complied with, resulting in a considerable amount of extra cost and difficulties at certain locations.

Both from the standpoint of appearance and maintenance requirements, concrete or concrete-protected viaducts were called for and this involved heavy loads to be carried. It was a general understanding that the street traffic must be maintained



SECTION OF RETAINING WALL ALONG CANAL ST. AT END OF ADAMS ST. VIADUCT.

as much as possible during the period of erection and that the viaducts might have to be constructed in two halves. A concrete-protected steel structure with a solid concrete floor was chosen as the type most desirable, both on account of the span lengths, often unsuitable for a strictly reinforced concrete structure considering the available floor depth, and on account of the greater elasticity permitted in the manner of erection of a steel structure.

Gunite for protection was considered and used in certain instances, but generally the structural steel members were encased with poured concrete. One objection to gunite was the small floor depth available which demanded that the roadway slab be supported below the top flanges of the girders, an arrangement obtainable with a poured concrete web encasement; another objection to gunite was the considerable cost of doing this work under railroad traffic.

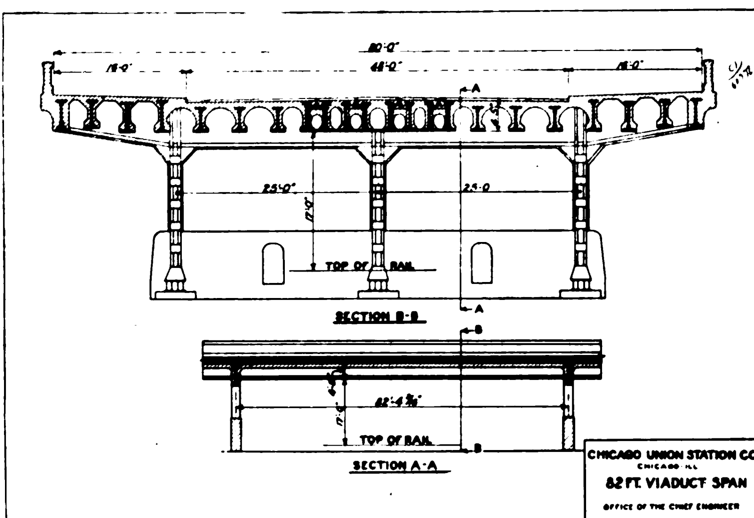
In deciding upon the type of foundations to be used, the City requirements in regard to provision for future subways in all streets had considerable weight. It necessitated either the elimination of a center column in the column bents and the introduction of a deep and unsightly cross girder over the passenger platforms, or that the center column be carried by the means of a foundation girder resting

on the side column supports. The latter method was chosen. The column loads were generally so heavy that a spread footing on the soft clay was impracticable and a pile foundation, although possible, would be very expensive and undesirable. The great ease with which a concrete caisson can be sunk in any location without the need of much headroom for equipment was another reason why this kind of foundation was finally decided upon and used in practically all instances.

The foundation caissons were generally from 4 ft. to 5 ft. in diameter, two for each column bent, spaced to allow about 36 feet clear opening along the center line of the street. Usually hardpan was found at an elevation about —50 to —60, at which elevation the caissons were belled out sufficiently to limit the pressure on the ground to about 6 tons per square foot. Concrete in the caissons was plain, of about 1:2:4 mix, with stress limited to 450 lb. per square inch. They were stopped deep enough in the ground to permit of being capped with a reinforced concrete foundation girder which suports the center column. As the span was considerable, these foundation girders are large, sometimes as much as 5 ft. wide, and 9 ft. deep, heavily steel reinforced for moment and shear. They had to be low enough in the ground to permit the column base to be below the platform elevation.

All viaducts, except Jackson Boulevard, carry street railways and the superstructure was designed for concentration from two lines of 50-ton cars on each track and 100 lb. live load per square foot of unoccupied roadway and sidewalks. All portions of the floor were also designed to carry a 24-ton truck.

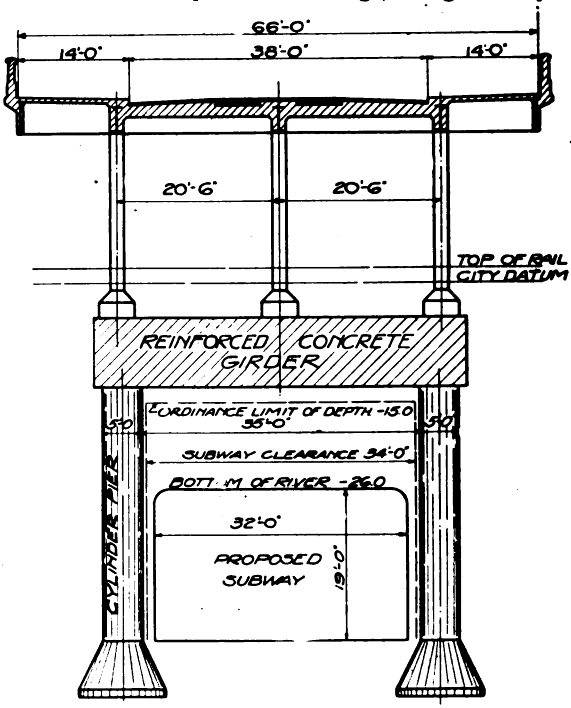
It was thought desirable to provide expansion joints in the longer viaducts, at intervals of about 300 ft., while the street railway company made a strong claim for welding the rail joints throughout. At the request of the City Engineering Department the street railway tracks, which consist of 9-in. rail on 4-in. steel ties laid in concrete, were therefore separated from the concrete roadway slab by a cushion of about 2 in. of screenings with a view of obtaining independent movements of the viaduct and the track structure. (This view was not shared by the Station Company's Engineering Department and experience has later indicated that existing friction and adhesion between track structure and concrete roadway slab is too large to permit of independent movement.) For this purpose a trough was provided for the car



CROSS SECTION OF TYPICAL VIADUCT CARRYING STREETS ACROSS THE STATION PROPERTY.

tracks at the center line of the street, 17 ft. 2 in. wide and 1 ft. 3½ in. deep, which materially reduces the depth available for steel construction. Two inches was generally allowed for concrete protection underneath the girder flanges and another minimum of 2½ in. allowed for membrane waterproofing with protection above the roadway slab.

The type of steel framing was governed somewhat by local conditions, such as available floor depth and location of the structure. If located in the station yard, ceilings were required over the platforms to prevent the formation of smoke pockets between girder webs, and in the case of Jackson Boulevard and Adams Street, the installation of a system for smoke ventilation was called for. In all instances a column bent of three columns was used with the two outer columns placed near the curb lines and the span bridged by longitudinal girders which generally frame in to the columns. In the approach yard, cross girders frame in to the center column and cantilever over the side columns for the support of sidewalk framing and transverse knee braces are introduced to give added lateral stiffness. Intermediate framing is taken care of by longitudinal stringers framing in to the cross girders. In the station yard where the requirements were somewhat different, transverse beams or girders frame in to the three longitudinal girders and cantilever out to support the sidewalk. In the case of Jackson Boulevard and Adams Street viaducts, each requiring a smoke ventilation system, the transverse girders are spaced about 26 feet apart and form, with the longitudinal girders, floor slabs and ceilings, large compartments through which the smoke is taken out. Lateral stiffness is obtained by anchoring the columns securely to the foundations and by a strut or girder which frames in to all three columns at the top. Transverse knee braces were objectionable as they would project below the ceiling line and were considered unnecessary as all additional stiffness desirable is afforded by the heavy monolithic concrete floor construction.



TYPICAL SECTION OF VIADUCT AND PROPOSED SUBWAY

The specifications which allow a normal

bending stress of 16,000 lb. per square inch for steel in bending, provide that for shallow girders and beams the unit stress must be decreased to such an extent that the deflection will not be greater than in a girder with a depth of 1/12 of the span. For this reason, in a great many cases, the fibre stress in the steel girders throughout the viaduct work had to be kept very low and in certain instances the specifications were difficult to comply with. As already stated, in the approach yard, at Polk and Taylor Streets, the spans over the six station tracks are approximately 83 ft. and the entire available floor depth from top of street car rail to lowest projection is only 4 ft. 5 in. It would have been impossible to design these spans without introducing a system of girders projecting above the roadway if the stresses were kept as low as the specifications demanded, but in consideration of the very heavy dead-load stresses as compared with total stresses, permission was granted to use a fibre stress in bending of 12,000 lb. per square inch, with the understanding that the girders be cambered an amount equal to the combined dead and live-load deflection. Nevertheless it was necessary to change the usual construction of the street car tracks in order to gain depth to place two twin girders spaced about 2 ft. 5 in. center to center under each rail and to support the rail as low as possible between the girder flanges on a special support connected to the girder webs. The twin girders were about 44 inches deep out to out of cover plates and had flange areas of about 70 square inches each. Other roadway girders in the span, which were spaced about 5 ft. center to center and had to be still shallower toward the street curbs, were only 40 in. out to out of cover plates, with a flange area of about 120 square inches.

THE METROPOLITAN ELEVATED RAILWAY, JACKSON BLVD. AND VAN BUREN ST. VIADUCTS SPAN THE SOUTH TRAINSHED.

For the sake of appearance the bottom of the concrete fascia of the span was carried on the same level as the rest of the viaduct, 3 ft. 10 in. below sidewalk level, which necessitated very shallow sidewalk girders.

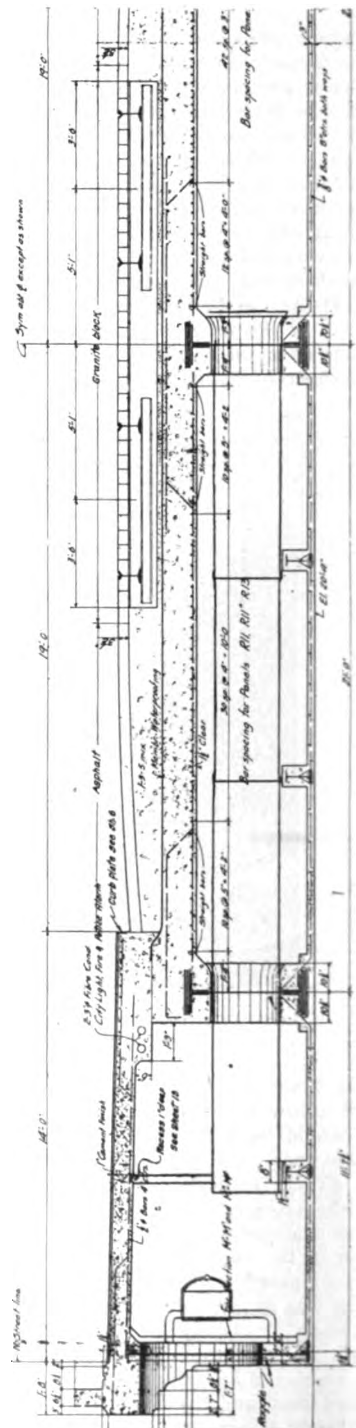
At the time this particular structure was designed, fear was expressed that with the extremely shallow steel construction great and undesirable vibration would be experienced. This contention has not proven to be true; the dead weight of the span is proportionally so large that vibrations due to the passing of trucks and street cars are hardly noticeable.

Concrete for encasement and for roadway and sidewalk slabs was of about 1:2:4 mix, steel reinforcement being deformed bars of the intermediate grade. Cement grout was used in concrete protecting the underside of beams and girder flanges and the flanges were wrapped with wire mesh. Columns on passenger platforms are provided with an ornamental iron encasement, harmonizing with the treatment given the trainshed columns, and the iron encasement is filled with concrete. Columns outside the trainshed area are wrapped with wire mesh and concrete encased and the column bent provided with a protection pier 2 ft. to 2 ft. 6 in. wide and 5 ft. high above top of rail.

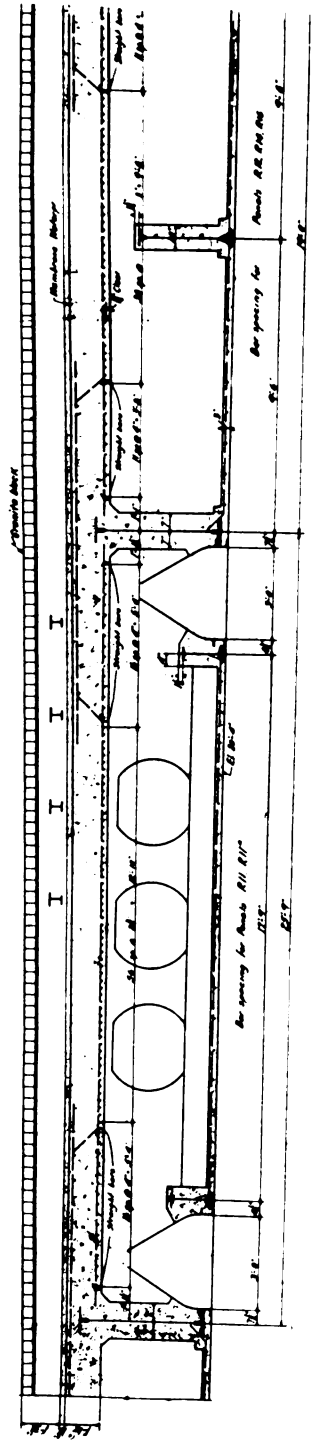
The roadway slabs are generally from 9 to 12 in. thick, reinforced to make a continuous slab over the entire floor. A 2½-in. to 3-in. concrete ceiling has been provided over the passenger platforms and in the case of Jackson and Adams Streets extended underneath the entire viaduct floor for the purpose of providing smoke chambers over the tracks.

Generally an asphalt and saturated cotton cloth membrane is applied on top of the roadway slab, consisting of four swabbings of bitumen, one layer of felt at the bottom as a protection against puncture of the membrane, two intermediate layers of saturated cotton cloth and finally on top a protection of vulcanized prepared roofing paper—seconds. The concrete fill required on top of the waterproofing to bring the grade up to the underside of the paving was made of a lean mixture. Minimum protection of concrete over waterproofing membrane was held to 2 inches.

Particular attention had to be given to the waterproofing of Canal Street between Jackson Blvd. and Adams Street, which forms the roof over the passageway between the main waiting room in the Headhouse and the Concourse. The floor depth available was very shallow and the longitudinal steel floor framing consists of heavy I-beams placed about 2-ft. centers. On these beams were placed ⅜-in. steel deck plates, which cover the entire roadway. The plates which were riveted together were bevel sheared at the joints and caulked to be prefectly water tight. As an added precaution an asphaltic cement was applied along the full length of the joints over a width of about 9 in.



CROSS SECTION OF PART OF ADAMS ST. VIADUCT SHOWING DUCTS FOR SMOKE REMOVAL.



PART LONGITUDINAL SECTION OF ADAMS ST. VIADUCT SHOWING SMOKE OUTLETS.

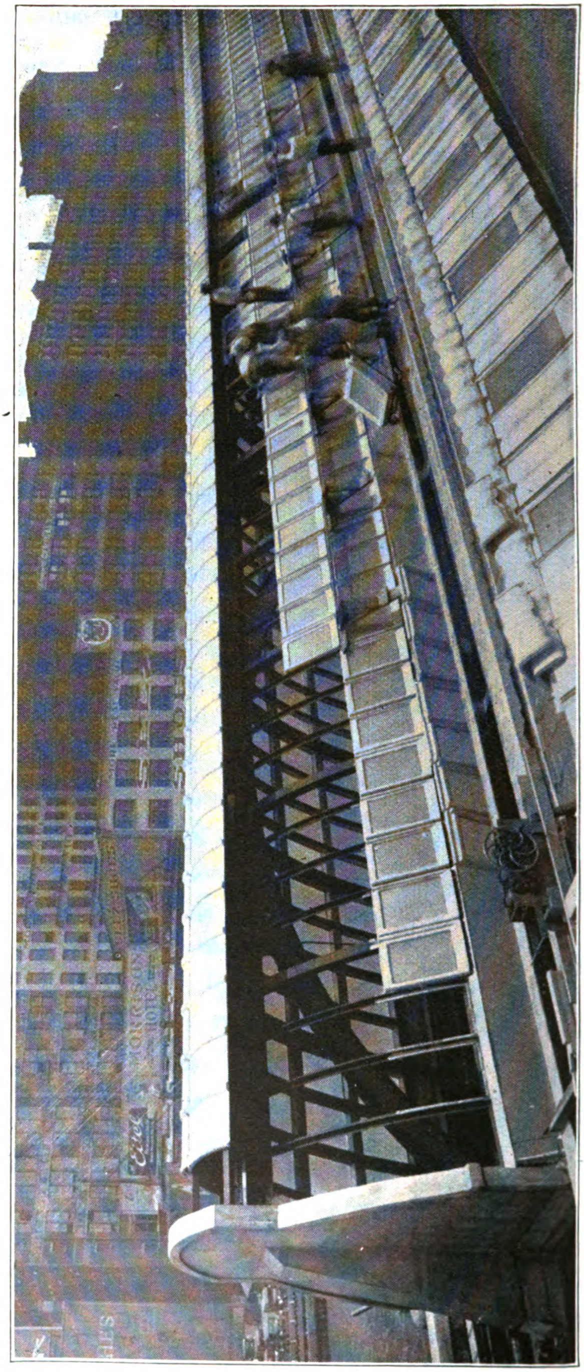
The reinforced concrete roadway slab was poured next on top of the steel plates and this slab is waterproofed with an asphalt membrane waterproofing, on top of which comes a lean mixture of concrete fill and finally the asphalt paving.

Cast iron plates ½ in. thick and 3 ft 6 in. wide were provided under all beams and girder flanges over each track to protect the concrete encasement against locomotive blast. In the case of the smoke chambers formed in the floor system of Jackson Boulevard and Adams Street viaducts, all interior exposed concrete surfaces were treated with "Ironite."

Conduits for public utilities are generally fibre conduits and some times placed in the roadway slab, but more often arranged along the street curbs and concreted in with the sidewalk slab. Concrete boxes for handholes and manholes as required are generally located in the sidewalk and poured monolithic with the sidewalk slab. Concrete curbs along the roadway are guarded with ½-in. steel plates securely anchored to the sidewalk slab.

Paving on Canal Street is sandstone blocks laid in cement mortar, except the area between Jackson Boulevard and Adams Street facing the Headhouse and Concourse, which has a concrete asphalt wearing surface. This paving is also used on Jackson Boulevard, Adams Street and the River drive, surrounding the Concourse. Other east and west streets are mostly paved with a wood block pavement set in a pitch filler, although Roosevelt Road and a portion of Taylor Street has been paved with Durax granite blocks. All portions of the east and west streets adjacent to Canal Street where the approach grades exceed 1½% have also been paved with a stone pavement.

Drainage is provided for by specially designed cast iron grate inlets connecting with cast iron downspouts which are lead down along the viaduct columns to catch basins with outlets to the sewers or track drainage. The gutters are graded from a minimum depth of curb of about 4 in. to a maximum of about 9 in., with a minimum grade of about 0.5% although in certain particular instances the grade had to be made as small as 0.35%. Concrete sidewalk slabs are finished with a



PLACING THE CONCRETE TILE AND GLASS UNITS ON THE ROOF OF ONE OF THE TRAIN SHEDS.

1-inch mortar finish and are sloped towards the curb at the rate of ¼ in. to the foot.

As space would not permit of double column bents, expansion is generally provided for by introducing an extra cross girder, which is permitted to slide on the column caps.

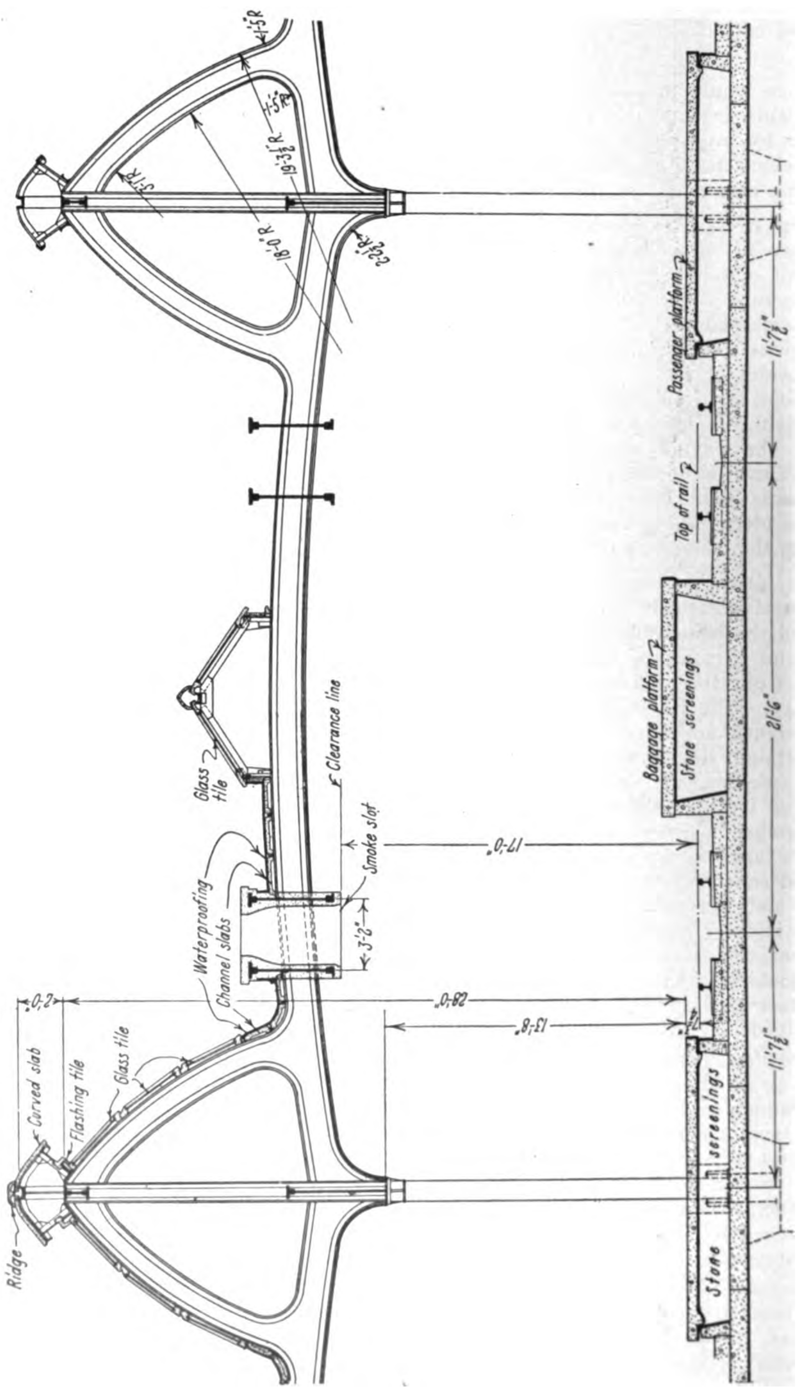
Bending stresses in the columns were taken care of, assuming a rate of expansion of one half of that of an open steel structure. The joints in roadway and sidewalk slabs were taken care of by a continuous lead flashing carried across the full width of the viaduct and by filling the joint with an asphaltic expansion joint cement. A steel plate is placed underneath the paving and permitted to slide. Where stone paving is used a ¾-in. elastic joint filler is provided between the blocks about every 30 feet, and also along the concrete curbs.

Careful attention was given to the architectural treatment of the concrete fascia and the balustrade walls along the viaducts on account of their prime importance from the standpoint of general appearance. The fascia girders were always designed so as to produce an unbroken straight line throughout the structure, irrespective of structural requirements, and were set back from the face of the parapet in order to distinguish between the function of the two. A poured, reinforced concrete wall, anchored to the sidewalk slab, forms the handrailing and this slab is faced with premoulded ornamental concrete sections forming a substantial looking parapet. The height was made 5 feet in the station zone area and 4 feet outside of this area.

A somewhat unusual arrangement was the placing of the signals on the fascia of the viaducts and doing away with unsightly signal bridges. The signal platform is supported by a system of pipes fastened to the concrete fascia by the means of expansion bolts. Pipe was used in preference to structural steel for the sake of appearance and maintenance.

At Adams Street and Jackson Boulevard, which are adjacent to the train concourses, it was deemed advisable to make special provision for taking care of the locomotive smoke undearneath the viaducts. The viaduct floor system is so constructed that the longitudinal and cross girders with the floor slab and ceiling form chambers over each track. Communication between the chambers is made by large round openings in the longitudinal girders. Right over the track and across the entire viaduct a slot 3 ft. wide has been formed in the ceiling slab and this slot is guarded on both sides by cast iron smoke deflection plates 2 ft. 6 in. high and tapering upwards so the smoke opening at the top of the plates is reduced to about 9 in. As the engine smoke is blown upwards and into the chambers of the viaduct floor construction, it is pulled out through an opening in the fascia girders above the trainshed roof by the means of an electric exhaust fan.

A quite interesting procedure was adopted in the reconstruction of the Metropolitan Elevated Railway viaduct over the station tracks. The old viaduct consisted of large truss spans supported on stone piers which interfered with the new station layout. The reconstruction of the viaduct provided for the retention of the entire floor system including floor cross girders, which latter were cut loose from the trusses and connected to two lines of longitudinal girders, one on each side of the viaduct. These new longitudinal girders which took the place of the trusses, were supported by columns located along the center of the new passenger platforms and in line with the new trainshed columns. This arrangement of reconstruction permitted of uninterrupted traffic on the viaduct during the construction period. The viaduct floor is just high enough to clear the trainshed roof and except for a top strut, the column bents, which are 35 feet high and kept entirely separate from the trainshed structure, have no bracing as such would pierce the trainshed roof and be very objectionable. To compensate for the absence of bracing the columns were designed strong enough for bending and anchored to large steel-reinforced foundation caissons in such a manner that the bending could be transmitted to the caissons and finally taken care of by the soil. This work was designed and executed by the Engineering Department of the



CROSS SECTION THROUGH TRAIN SHED SHOWING PLATFORMS AND TRACK SLABS.

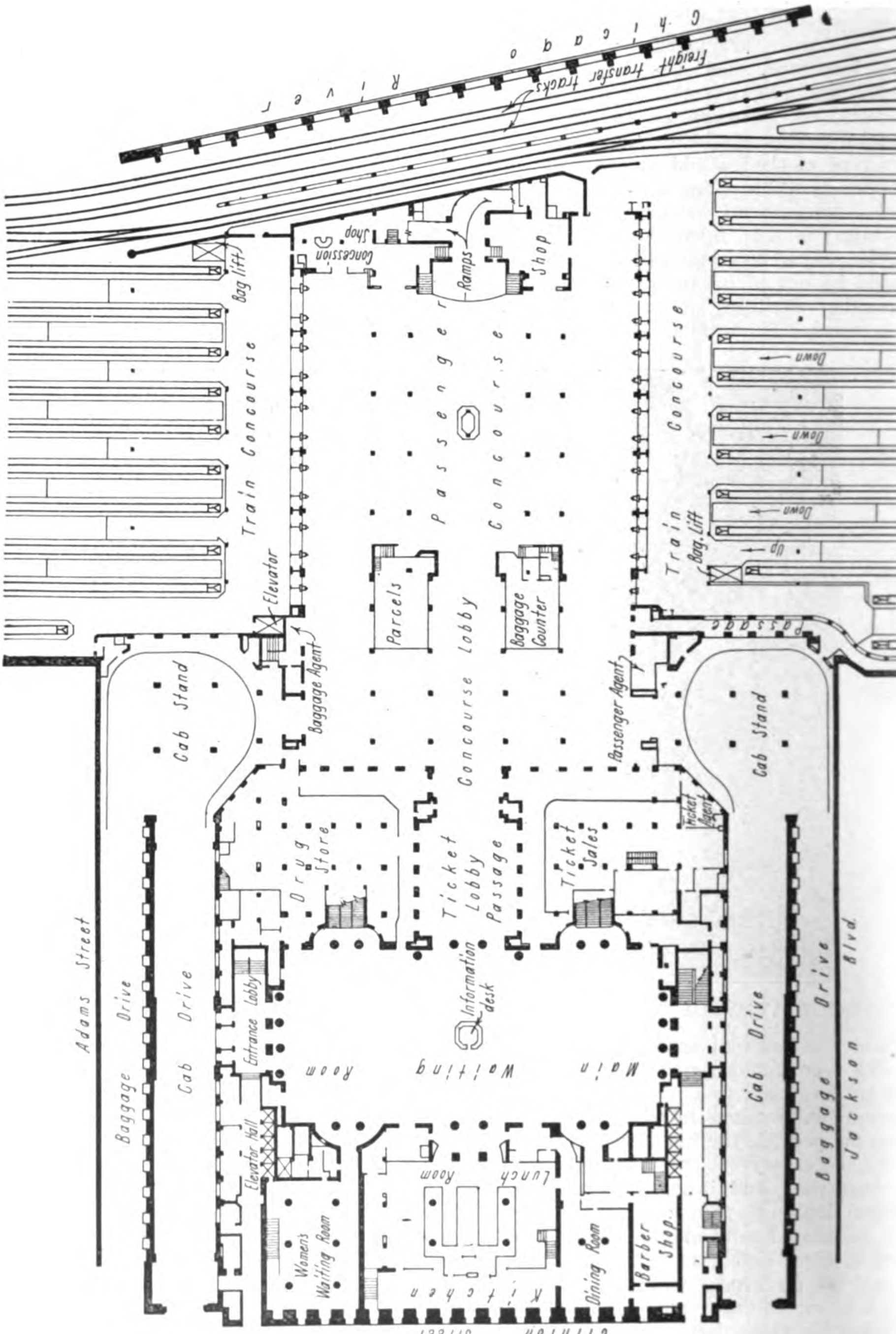
Metropolitan Elevated Railway Co., in co-operation with the Station Company.

Trainsheds

A low type shed was wanted, which would not obstruct the view from the viaduct. A butterfly or umbrella shed unquestionably would be the cheaper, but this type of shed would not give the protection desirable from driving rains and severe snowstorms, which often occur in Chicago; in fact, from the standpoint of service as well as appearance this type would be out of harmony with the plans for other facilities of the terminal improvement. The ordinary Bush shed possessed a feature of great merit in providing a continuous opening in the roof for smoke escape, but it did not meet the desired qualifications in other respects. It does not provide the headroom and ventilation necessary for comfort in the hot summer time and it is rather dark and gloomy looking. The original design of the trainshed, finally adopted, which differs only in minor details from the now nearly completed structure, was based upon a track layout calling for combined passenger and baggage platforms with platform height level with the car floor. At a later date, when the track layout was changed to provide for separate passenger and baggage platforms, the distance center to center of passenger platforms was only slightly greater (44 ft. 9 in.) and as the baggage platforms are too narrow to permit of columns being placed upon them, the original design still held good except for an adjustment of details.

The longitudinal spacing of the columns on the platforms was optional, but a longer spacing was naturally preferable as it would add materially to the capacity of the platforms and comfort of passengers. The provision desired for smoke openings in the roof required the construction of two continuous vent walls over each track and advantage was taken of this condition by making these walls do double service in acting also as the main longitudinal carrying members of the roof framing. For practical reasons the smoke vent walls need considerable depth and a longitudinal spacing of the columns was chosen about equal to the transverse spacing as being economical and the most desirable spacing from the standpoint of appearance with the treatment adopted for the cross frame.

INTERIOR VIEW OF COMPLETED TRAIN SHED FROM PASSENGER PLATFORM.

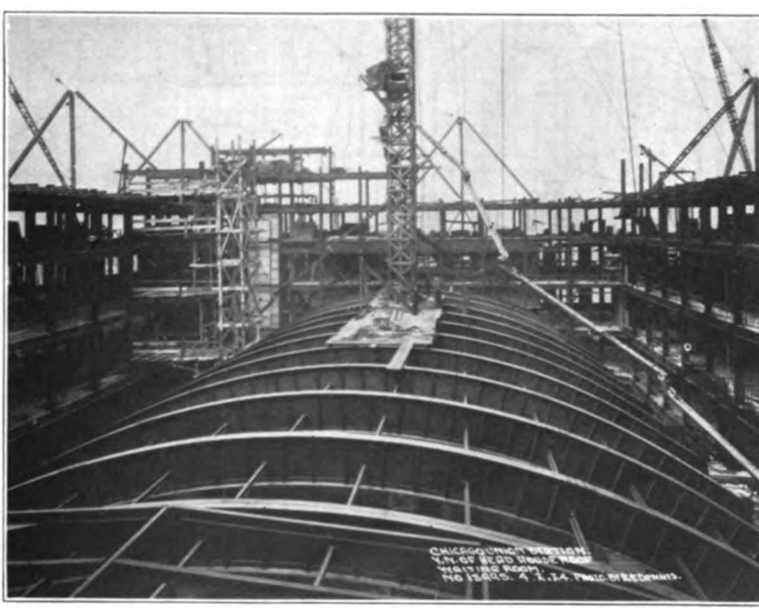


FLOOR PLAN OF HEADHOUSE AND CONCOURSE AT STATION LEVEL

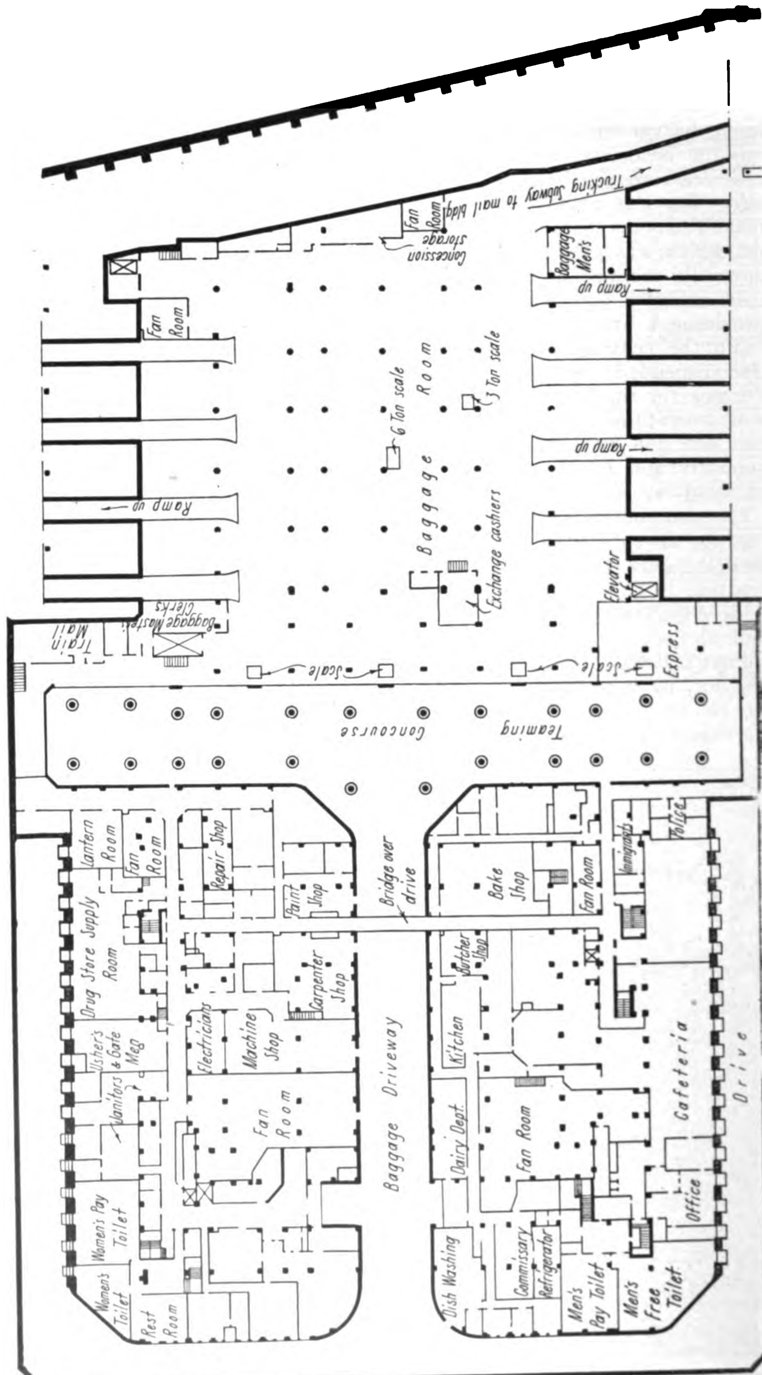
The smoke duct with its deep projecting concrete walls has been an unsightly thing in all former sheds where this feature has been introduced. In so far as taking care of the smoke, it is desirable that it should be carried down as far as possible, to the clearance line, and consequently at least to the bottom of the cross girder. For this reason effort was made to make the cross girders as shallow as possible, which was obtained by making the upwardly inclined monitor frame members an integral part of the cross girders, providing a bracket effect at the columns with the central portion of the cross girder suspended. Actually the entire cross frame for the full width of the shed acts as a continuous girder, shaped, as it were, with the web split over the column supports and the upper part of the girder bent up to act as monitor rafters. The continuous action of the cross frame was an aid in the erection as it eliminated the need of temporary supports to provide for unsymmetrical loading when the concrete vents were poured and the roof tiles set.

Longitudinal stiffness of the steel frame is provided for by a shallow top strut connecting to the columns and by a system of arches. The longitudinal arches, which take the place of knee braces otherwise required, provide a freer, less obstructed headroom and more pleasing appearance than another system of bracing would provide, but add, of course, somewhat to the cost. The intermediate steel framing consists of beams supported by the smoke vent girders and, at the top of the monitor, also supported by the longitudinal column arch brace. For the sake of appearance, intermediate beams over passenger platforms were made bulb beams. A secondary framing of importance provides for a continuous opening at the top of the monitor roof to furnish additional ventilation. It was found that economy could be had by draining the entire length of roof between viaducts, some 400 lineal feet, to one downspout per platform. For this reason the monitor framing had to be set far enough back from the smoke vent girders to allow for adequate large gutters or troughs which are formed by the curved roof tile and the concrete smoke vent sides.

Premoulded concrete tiles with glass inserts were chosen for roof covering as being economical, substantial in appearance and in keeping with the rest of the work. The gutters are waterproofed with



ARCHED GIRDERS SPAN THE MAIN WAITING ROOM, WHICH IS 100 FT. WIDE



PLAN OF BASEMENT LEVEL OF HEADHOUSE AND CONCOURSE.

a built-in asphalt roofing. Three sections of glass tiles of a combined length of about 9 ft. on each side of the monitors provide a continuous skylight over the passenger platforms. Skylights over the baggage platforms are provided for by making every third roof tile of 24-in. width and 52-in. length a glass tile. The edges of the glass, which is ¼-in. wire glass, are dipped in a hot asphalt preparation and concreted into the tile. The tiles have overlapping horizontal joints and the specially formed vertical joints are filled with an oil cement filler and covered with a coating of elastic compound.

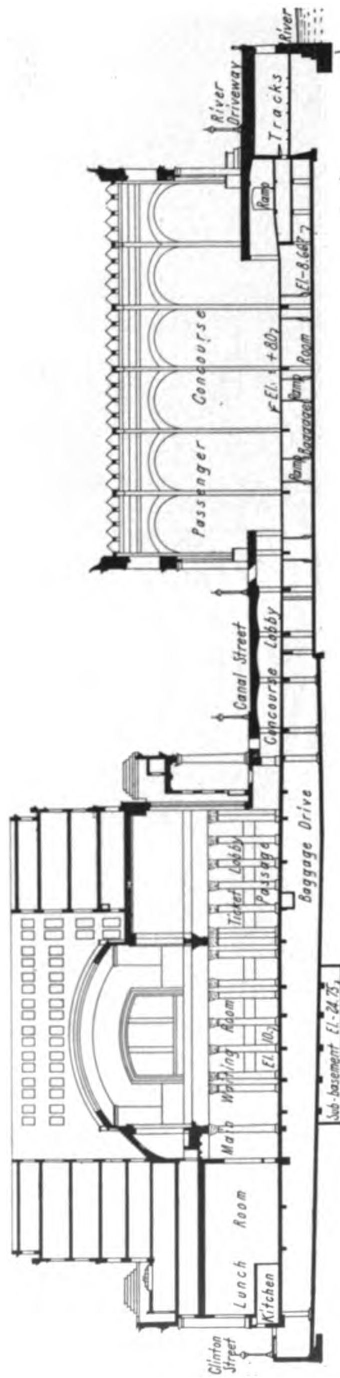
The columns up to the bottom of connection of cross frames and arch braces are provided with an ornamental iron encasement. Continuous cast iron protection smoke guards are provided under the concrete encasement of the smoke vent girders and also under the concrete encasement of the cross frame girders over the tracks.

The column loadings, which are comparatively small but too large to be carried on a spread footing formed by the platform construction without considerable extra expense, were provided for by constructing shallow 4-ft. concrete caissons about 25 ft. deep, which together with a 10x10-ft. reinforced section of the concrete slab underneath the platforms and on top of the caissons act as foundations.

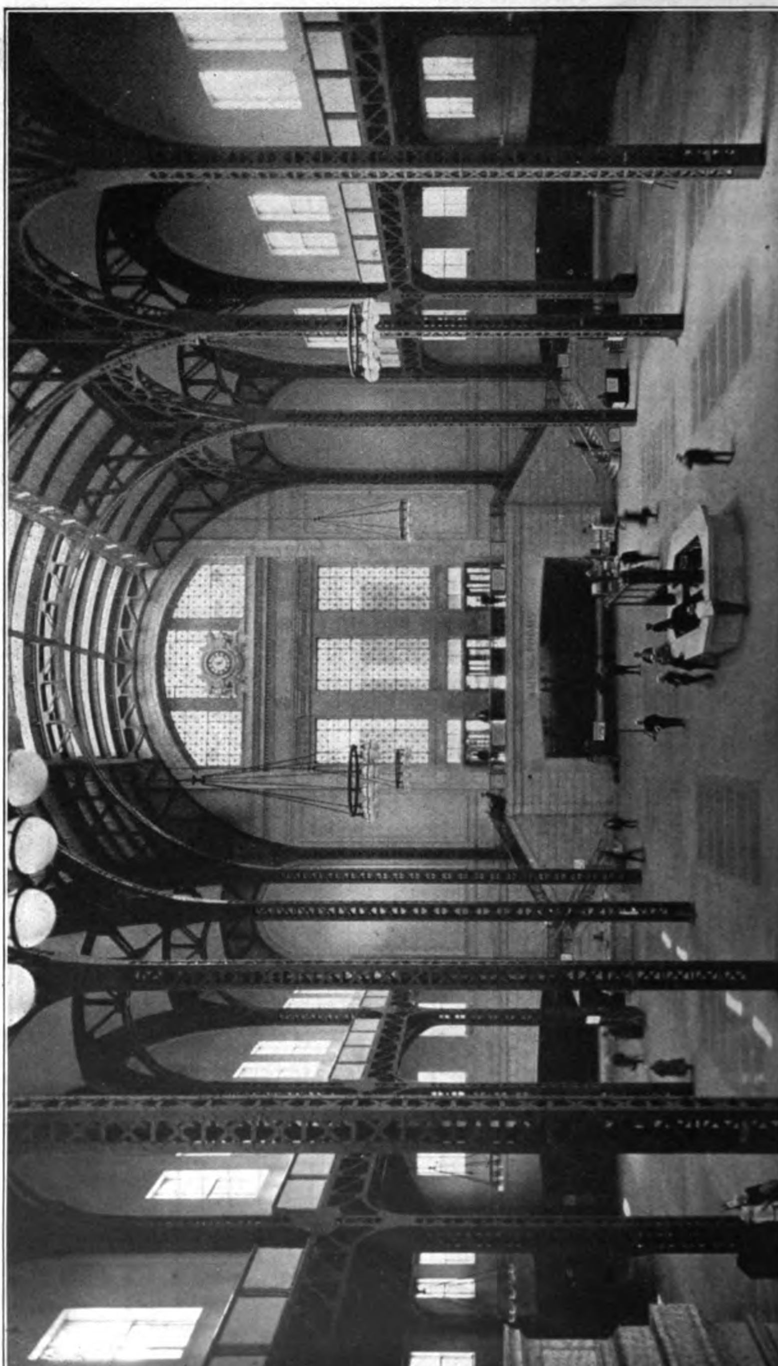
A description of the trainshed by Mr. Lacher is found in the Railway Age, July 4, 1925, issue.

Headhouse and Concourse

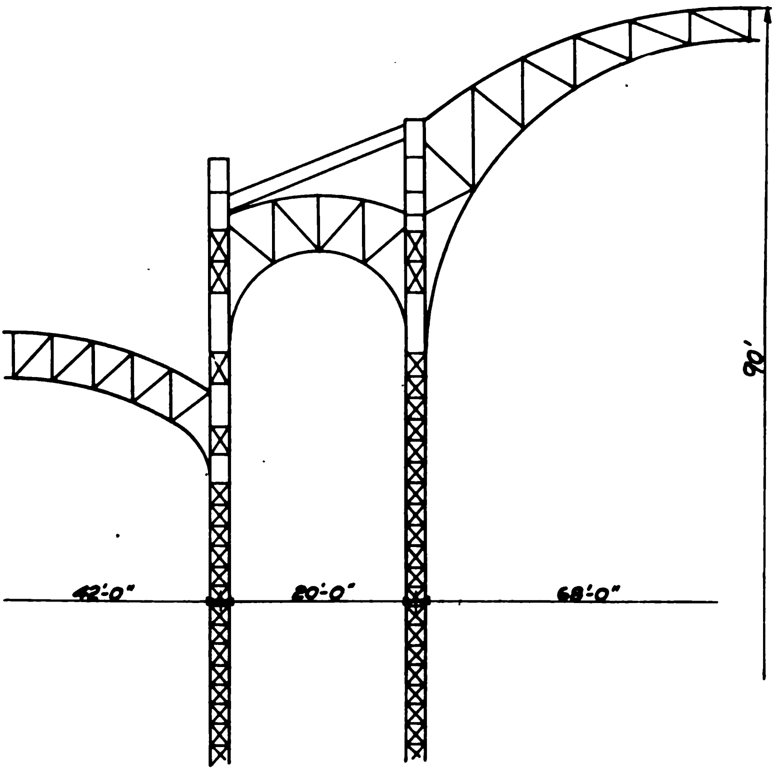
The Headhouse foundation problems were made more difficult when the decision was made to change from a low monumental structure, essentially for station purposes, to a combined station and 24-story office building. At the time of this decision foundation caissons were already in place for the building as originally planned, and effort was made to arrange the revised column layout so as to be able to use as many of the old foundations as possible. Nevertheless, not only revisions in the general layout, but the greatly increased loadings made it necessary to construct a large number of additional caissons and in many instances support the columns on large reinforced concrete girders resting on one old and



CROSS SECTION THROUGH HEADHOUSE AND CONCOURSE.



INTERIOR VIEW OF THE CONCOURSE SHOWING PASSAGEWAY UNDER CANAL ST. LEADING TO THE HEADHOUSE AND STAIRWAYS TO THE STREET.

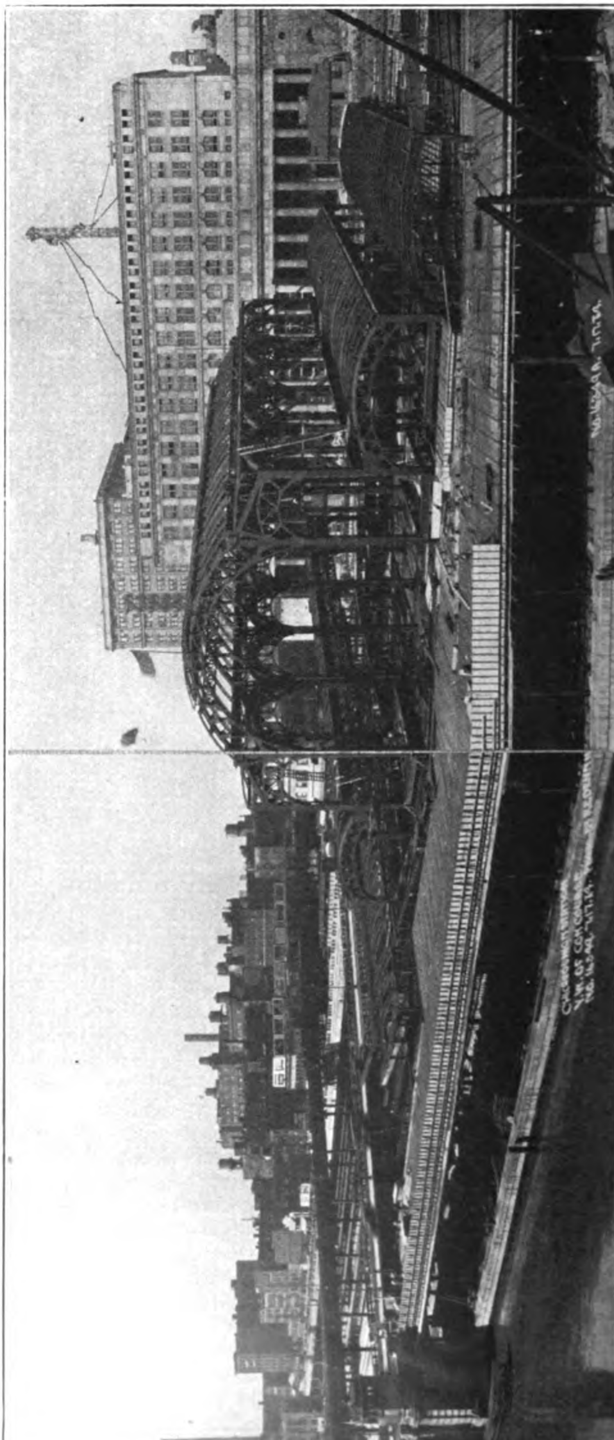


PART CROSS SECTION OF CONCOURSE

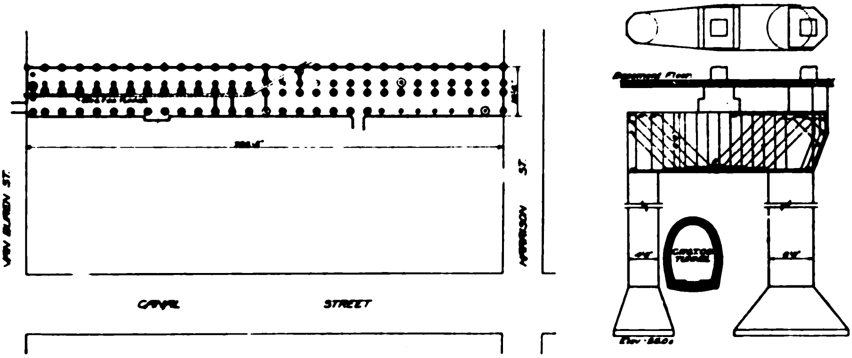
one new caisson. The caissons are from 4 ft. to 10 ft. in diameter and stop in hardpan at an elevation between —60 and —66 (about 90 ft. below street level). The old caisson bases were designed for a maximum pressure on the ground of 6 tons per square foot. In the case of the additional caissons, however, many of which carry a large loading and are located near old ones, a limit of 6 tons per square foot would make the new bells overlap old ones, and in certain instances create a situation impossible to solve. The full sized caisson tests which were undertaken showed definitely that a loading of 10 tons per square foot on the hardpan is conservative and this loading was adopted in the design of the revised foundation layout. In order to minimize the diameter of the additional caissons the concrete was made rich, of 1:1½:3 mixture and designed for a maximum pressure of 500 lb. per square inch. The concrete in the old caissons was of 1:2:4 mixture and the pressure limited to 400 lb. per square inch.

Retaining walls along Jackson, Adams and Clinton Streets are self-supporting cantilever slab walls provided with a wide projecting toe, which is supported near the outer edge on one row of wooden piles. Retaining walls for the sub-basement and baggage room under the Concourse are slab walls supported at top and bottom, resting on caissons. The walls around the Headhouse block are membrane-waterproofed, other walls are waterproofed with an integral waterproofing. Basements slabs are 12-in. plain concrete laid on 6 in. of cinders with open tile drains underneath the slab and catch basins connecting with sewer draining to ejector pits in the sub-basement.

In general hollow tiles are used



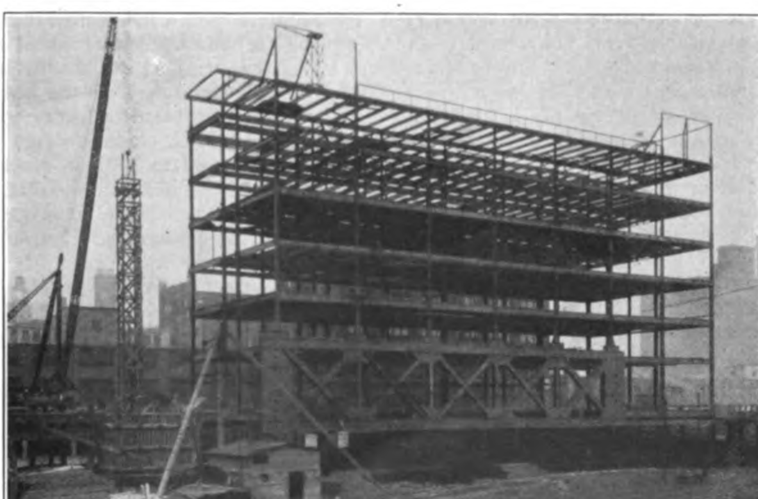
GENERAL VIEW SHOWING CONCOURSE FRAMING COMPLETED AND HEADHOUSE IN THE BACKGROUND



FOUNDATION PLAN FOR MAIL BUILDING SHOWING GIRDERS REQUIRED TO SPAN EXISTING FREIGHT TUNNEL.

throughout the Headhouse for fireproofing of steel and for floor construction. Concrete driveway floors are carried on structural steel encased in concrete and sub-basement floors are of reinforced concrete.

The most conspicuous part of the steel framing is that surrounding the upper portion of the Waiting Room between the 6th and 8th floor level, particularly the provision made for carrying the office building above the balconies at the north and south ends of the waiting room. The box-section truss provided spans about 80 ft. and occupies nearly the depth between the 6th and 8th floors. Six triple girders, supporting the columns above, rest on top of the truss and cantilever out to support the court wall columns and are provided with hangers to support the 7th floor below. The total load transmitted from the two lines of the office building columns to the 80-ft. truss below is slightly more than 4000 tons. The truss



HEAVY STEEL FRAMING WAS REQUIRED TO SPAN THE TRACKS ENTERING THE MAIL BUILDING.

is connected to the columns by means of gusset plates 10 ft. wide, 23 ft. long and 1 in. thick, and has a maximum chord stress of more than 4,000,000 lb., and a chord area of about 260 square inches. The central section of the top chord shipped loose for erection weighs about 75,000 lb., and was the heaviest piece to be lifted in the erection of the structure.

The steel framing for the sides of the building flanking the ends of the waiting room is limited to two lines of columns spaced about 9 ft. center to center for a vertical distance of several floor heights and added stiffness has been provided by a system of bracing at each floor level and by braces to the large truss.

The framing for the 100-ft. wide waiting room ceiling consists of arched girders 4 ft. 8 in. deep framing into independent columns set back from the other building columns about 16 feet on either side of the room.

The concourse structure is also supported on caissons. The steel framing below the concourse floor, which is of reinforced concrete and forms the roof for the baggage room, is all encased in concrete. The concourse roof structure which is an open steel construction covered with concrete tiles and skylights, was designed with a view of obtaining a large and lofty room of proper dignity but without a formal treatment. Studies indicated that a single roof span would require too massive steel construction and that the introduction of two intermediate lines of columns offered the better solution. The central arch is not a true arch, but each half is designed as a cantilever anchored to the outer row of columns by a structural member which is enclosed by the arched roof ceiling above the lower arch. The shop work on the steel throughout is of a very high standard and it may be noted that the specifications or the manufacture call for no other requirements than what is usual for ordinary building work except that curves must be true and joints must have close fit. The curves in the plates were first burnt and then ground.

Mail Building

The basement walls are constructed as reinforced concrete slab walls supported at top and bottom. They are waterproofed with an integral waterproofing. Column foundations are caissons sunk to hardpan at an elevation about —50. All framing is structural steel encased in concrete with reinforced concrete floor slabs. An unusual feature about the building, besides its dimensions, is the very heavy steel truss which was required in order to permit of a side track into the building. The truss occupies two stories in height (or 28 ft. 8 in), carries four 6-story wall columns with a total load of 4050 tons and has a span of about 150 ft. The top plates of the box section chord are 20 in. wide and 5½ in. thick, and the truss weighs about 364 tons. Two inches camber was provided but only the smaller portion of this was taken out by deflection after the truss received its total dead load. The caissons supporting the columns are 9 ft 2 in. in diameter and the bases are belled to a diameter of 24 ft 6 in. in hardpan at an elevation —51.

Power House

The power house has also structural steel framing encased in concrete and reinforced concrete floor construction. Foundations are caissons sunk to hardpan. The building distinguishes itself by carrying its brick stack 175 ft. high and 12 ft. inside diameter, on top of the roof by means of a system of heavy steel girders supported on independent columns which are braced to provide for the wind stresses. The stack was placed on the roof as the most desirable location with respect to the boiler layout, as well as to general appearance.

The buildings were designed by Graham Anderson, Probst & White, Mr. C. F Wm. Braeger, Chief Structural Engineer. They also prepared the detail design for the Trainsheds.

Mechanical Features of the Chicago Union Station

By Edison Brock,* M. W. S. E.

Presented October 5, 1925

In presenting this paper, Mr. Brock said that in one way the Union Station might be compared to an iceberg, which floats with eighty-five per cent of its mass below the surface of the water. The same is true of the station. Few persons using the station realize the great amount of work which lies beneath the surface. The mechanical equipment described herein is a representative example of this comparison.—Editor.

Purchase vs. Generation of Steam and Electricity

BEGINNING in 1915 the engineers of the Chicago Union Station Co., in co-operation with the architects, Graham, Anderson, Probst & White, entered into an analysis of the cost of steam and electricity if purchased, in comparison to the cost if generated in a power station owned by the company. These studies were interrupted and materially changed by the World War but were resumed on renewal of work on the terminal.

Drawings were made of power houses and the most practical of these schemes completed so as to include equipment, piping, etc. Bids were obtained on the equipment and careful estimates made of cost of building and contents, from which the annual fixed charge for interest, tax, depreciation, etc. was determined for each condition.

In order to ascertain the annual operating charge, it was necessary to estimate as carefully as possible not only the total steam and electrical load but to prepare curves showing the relation between steam and electrical demand throughout the day and year, as utilization of exhaust steam for heating purposes, was important.

The general practice of using average monthly temperatures was considered too inaccurate to determine the heating load and instead, a table was compiled from records of the United States Weather Bureau for Chicago covering a ten-year period wherein the heating season was divided into hours elapsed at each 5 deg. group of temperatures from —10 deg. to 70 deg. For each temperature the heating load was calculated and this tabulated against the available exhaust as determined from electrical load curves and steam turbine operating data.

It was found that non-condensing turbines could not compete with the purchase of electricity at prices available on a load of the size required also a combination of condensing and non-condensing turbines was too great in first cost and not sufficiently flexible to give best economy. Bleeder type turbines, that is, units permitting withdrawal of steam at atmospheric pressure for heating purposes, also variable vacuum turbines were then considered. With the latter it was proposed to do all building heating by a forced-circulation hot water system, the water being circulated through turbine condensers at a vacuum depending upon weather conditions, so that throughout the heating season the turbine would operate through the full range from condensing to non-condensing at corresponding steam rates. During the non-heating season, condenser water was to be obtained from the Chicago River.

The margin of saving possible under these schemes was so slight that it was decided to purchase 12000-v., 3-phase, alternating current from the Commonwealth Edison Co. and to build a plant for generating steam and furnishing compressed air. The following were important factors in this decision:

(a) The power house location at approximately 2000 ft. from the load center of the principal group of buildings required generation of electricity at high voltage and substations at the load centers comparative in cost to those required under the purchase plan.

(b) Completion of the Mail Terminal

* Mechanical Engineer, Chicago Union Station Co.

two years in advance of other buildings complicated an electrical plant building program.

(c) Labor and material were advancing in cost as against a fixed purchase charge for electricity.

(d) Possibility of addition or omission of buildings might materially affect the steam and electrical requirements.

Boiler House Location and Building

The boiler house is located on a triangular-shaped piece of land between the station tracks and Canal St., north of Harrison St. While this necessitated long high-pressure steam mains, it removed the dirt and annoyance due to the handling of coal and ashes from the vicinity of the station, also avoided building of large chimney in connection with the head house and left all tracks free for the use of passenger trains. In order to leave the corner at Harrison and Canal Sts. free for a future building, the power house was located as far north as the converging sides of the triangle would permit and advantage was taken of the space under Canal St. sidewalk for the coal and ash handling track. In this location the coal and ash handling is hidden, by the building, from the public view either from street or passenger tracks—an unusual feature in a boiler plant of this size.

The boiler house faces on Canal St., the boiler room floor being at track level approximately 20 ft. below street level, with basement under the firing aisle and 12 ft. lower, and the roof 50 ft. above the firing aisle. The building is 163 ft. long and 48 ft. wide, except that the north end tapers to 24 ft. in width, the east wall following the line of tracks. The building is of Kittaning brick with flat roof and simple outline being purposely so treated on account of its low elevation as compared to the street. Architectural prominence is given to the chimney which is 12 ft. internal diameter and extends 225 ft. above grates and is supported directly by the roof. It is constructed of radial brick with an outer surface of Kittaning brick and has a massive ornamental terra cotta base, octagonal in shape and 25 ft. in width at roof line.

Boiler Plant Equipment

The equipment in the boiler plant consists of the following:

Six Babcock & Wilcox "Stirling" boilers, four of 610 hp. set in batteries of two each, and two of 328 hp. set in battery, total capacity 3096 b.hp. The smaller boilers intended for summer loads are the same in cross section as the large ones but not so wide, thus maintaining the same boiler height and depth.

Six natural draft Green chain grates, furnished by the Combustion Engineering Corp., guaranteed to develop 200 per cent rating.

One 4400-hp. Warren Webster open type feed water heater. Water flows to this heater from an overhead receiving and make-up tank 5 ft. in diameter by 14 ft. long.

Two Manistee Iron Works "Roturbo" 4-stage, centrifugal boiler feed pumps, 210 gal. capacity each driven by Terry steam turbines.

Two Worthington, 7½x4½x10 in. steam driven reciprocating pumps for boiler washing and summer boiler feed.

Two Bury cross compound steam, 2-stage air compressors with inter-cooler and after-cooler, with capacity of 500 cu ft. of free air per min. Terminal air pressure 70 to 90 lb. In addition to the after-cooler, there is an extensive pipe condenser outside of wall further to guarantee dry air. Air is used principally for the interlocking system and in addition serves pneumatic ejectors, miscellaneous tools and barber shop and is used for cleaning motors.

One Westinghouse 9½x11x10 water-jacketed steam-driven air compressor to boost air pressure from 70 to 110 lb. for air brake testing.

One Chicago Pump Co. 150 gal. per min., motor driven centrifugal duplex sewage ejector.

In addition there are one blowoff tank, 2 air storage tanks, 1 domestic hot water heater and miscellaneous small equipment. Boilers are equipped with Vulcan soot blowers, Republic draft indicators, Republic CO_2 recorders and Gray damper regulators.

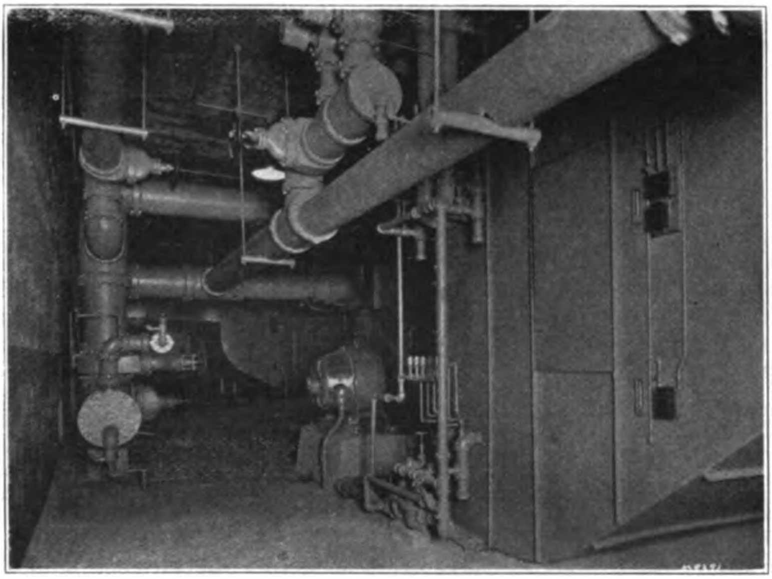
Coal and Ash Handling

This equipment was furnished and installed by the Webster Mfg. Co. and has

a capacity of 40 tons per hour. Coal is dropped from railroad cars into the 14x 18-ft track hopper beneath Canal St. sidewalk and adjacent to the firing aisle. From the hopper it falls on a 30-in.-wide apron feeder which delivers to a 24x30-in. double-roll crusher mounted over the lower run of a 24x18-in. pivoted-bucket conveyor. This conveyor follows a rectangular course rising above coal and ash hoppers at one end of the firing aisle and dropping to the basement again at the other. Coal is deposited in a continuous hopper framed into the building steel, 97 ft. long, 16 ft. wide and 25 ft. deep, the bottom converging at center hopper. This is framed into building steel north of coal hopper and has a steep bottom so that ashes flow by gravity into railroad cars. It is lined with 6x9x1-in. vitrified shale tile laid in ½-in. cement bed, steel surfaces first having been coated with Bitumastic asphaltic solution and Hermastic enamel. The ash hopper is 17 ft. long, 16 ft. wide and has a capacity of approximately 4,000 cu. ft. The coal and ash handling system is simple, reliable, and of well established design.

Feed Water Arrangement

The chief source of feed water is the condensation returned from the heating



FAN ROOM SHOWING MAIN STEAM DISTRIBUTION CENTER AND THERMOSTATIC CONTROLS ON FANS.

from a side wall depth of 15 ft., giving a capacity of approximately 800 tons. Coal is withdrawn through one of 15 equally spaced gates in bottom of hopper into a 200-lb. electric driven travelling weigh larry, where it is weighed and dropped by gravity into the chain grate hoppers. At the rear of grates, ashes drop into concrete ash pits so constructed that they flow with but little hand labor into the lower run of the coal and ash conveyor which elevates them to the ash storage system into the elevated receiving and make-up tank. The water then flows by gravity to the feed water heater and then to the feed pumps. It is delivered to the boilers through either the main or auxiliary feed water line, each equipped with Venturi tube connected to a Republic flow meter. The records from this meter, together with the weight of coal from scale on traveling weigh larry, give a continuous record of pounds of steam produced per pound of coal. S. C. feed

water regulators automatically control the level of water in boilers which are equipped with high and low-water alarms.

Steam Distribution and Condensation Return

Steam is generated at the power house at 125 lb. gage pressure and distributed to the buildings at this pressure. On account of the purchase of electricity, there is no exhaust steam except that from the air compressors and feed water pumps which is required in the feed water heater. A 12-in. main steam header, which is suspended from the roof over the top of the boilers, is divided by valves into three sections. Normally, these valves are kept open but in summer by closing the valves only the center section of the header is in use, any section of the header may be cut off for repairs, and the load carried from the remainder of header. This may be accomplished due to the fact that each section is served by a battery of boilers and each has independent distributing lines. The winter heating load is distributed through one or both of two steam lines each 2,200 ft. long. One of these is a 10-in. line and extends from the south section of the boiler header to the high pressure distributing center in the head house. The other, a 12-in. main, is connected to the north section of the boiler header and runs parallel to the 10-in. main to the same point in the head house. At the entrance to the Mail Terminal, an 8-in. service is taken off and the main reduced to 10 in. in diameter. A 6-in. line connects to the central boiler header section and extends 600 ft. to the steam distributing center in the south end of the Mail Terminal, and a 4-in. branch runs to the north end of Mail Terminal and is continued on to the distributing center in head house. In winter this 4-in. branch serves the heating load in the north end of Mail Terminal but in summer the 10-in. and 12-in. mains are shut down and the entire steam load distributed through the 6-in. line and 4-in. extension. A 6-in. main connects to the central and south boiler header sections and runs to the Burlington freight house south of Harrison street. There are two complete auxiliary steam headers in the power house, one connected to the north and one to the central main header sections. These serve the air compressors, feed pumps and stoker engines and are independent of each other.

The boiler header and distributing mains are of full weight steel pipe with extra heavy, flanged cast iron fittings. All joints are made with screwed companion flanges and Cranite gaskets except on long runs where flanges were installed at 60-ft. intervals. Extra heavy Crane valves are used in the power house, and medium pressure valves on distributing high pressure mains. Expansion is provided for by bends and offsets, except in long straight runs where Ross internally-guided expansion joints were used. Piping is suspended by means of trapeze hangers hung by ¾-in. bolts from inserts cast in ceiling, except in one trucking subway where it is supported by means of a heavy structural steel framework extending from floor to ceiling and bolted to the side wall.

Condensation is returned from the Head House and Concourse to Power House through a 6-in. main and from other buildings through smaller mains. The light pressure drips, kitchen returns and condensation from domestic water heaters are returned by American Steam Pump Co. duplex receiver-type units and the head house and concourse heating returns are handled by Nash centrifugal vacuum motor-driven pumps. The head house heating return unit is of interest, being of the Nash "Hytor" duplex type with single large receiver. Each half of this unit consists of separate vacuum and return centrifugal pumps driven by 30-hp. motors through Poole reduction gears and each is capable of handling 300,000 sq. ft. of direct radiation or its equivalent.

Robert Gordon, Inc., installed the steam and air piping in power house and distributing and return mains and the building heating and ventilating systems.

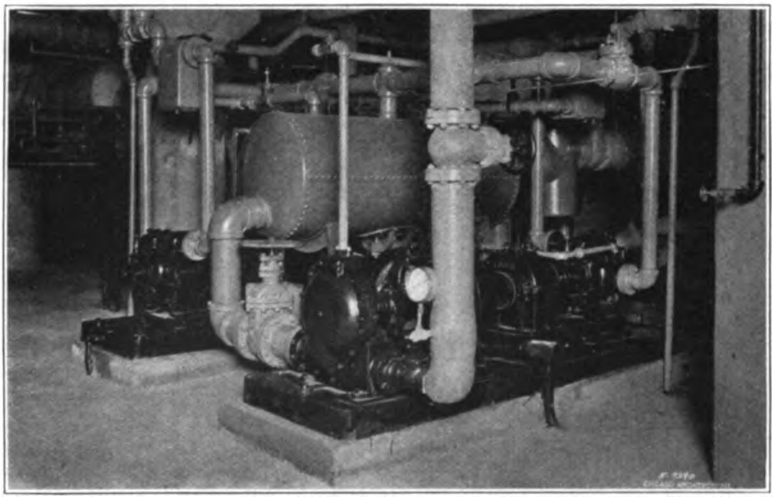
Heating and Ventilating

The primary source of heat for all building spaces is live steam transmitted to the buildings at 125 lb. pressure where it is reduced to low pressure by means of reducing valves. In general those spaces which do not require mechanical ventilation are heated by direct radiation. Those spaces requiring mechanical ven-

tilation are heated jointly by means of direct radiation and fresh air heated by indirect radiation.

The one principal exception to the above is the heating of the Mail Terminal upper floors. In this building the basement is mechanically ventilated and heat supplied through indirect radiation. The track and street levels are principally open to atmosphere and not heated. The upper floors do not require mechanical ventilation and are heated by a direct radiation system using forced circulation of hot water. Hot water was decided upon in order to avoid the problem of protection to condensation return piping of a steam radiation system. As this piping would have been on the ceiling of the unheated first floor and very extensive, the difficulty of protecting it would have been very great. Both supply and return mains of the hot water system are on the ceiling of the top floor and the branches drop to the second floor and return without entering unheated space. The water is heated in the basement pump room by means of two Sims heaters, each with a guaranteed capacity of 1,100 g. p. m. from 165 deg. to 195 deg. F. and is circulated by means of two American Steam Pump Co. horizontally split centrifugal pumps designed for a capacity of 1,100 gal. per min. against 30 lb. pressure and driven by Terry steam turbines. Steam supplied to heaters is metered by means of St. John steam meters. The water temperature is varied according to outdoor temperature and wind conditions.

The Head House occupies a full city block and includes sub-basement, basement and eight floors, surrounding the large main waiting room. Ultimately, the building is to be extended to 22 floors. The basement is divided into north and south sections by the central baggage drive and on the ceiling of each half is a two-pipe underneath vacuum system with risers extending to the eighth floor, where they are capped for future extension. The office floors are heated by a direct radiation vacuum system with Webster radiator traps and Dunham packless radiator valves controlled by hand. The entire basement, large public rooms, and practically all space at Main Waiting Room level and a portion of the second floor requires mechanical ventilation and is heated by means of fans supplying fresh warmed air supplemented by direct steam radiation. There is a fan room centrally-located in each half of the basement. Each half is approximately 100 ft. long with an average width of about 50 ft. In addition, there are seven smaller fan rooms in the Head House, two in the Concourse, two in the



CENTRIFUGAL VACUUM AND CONDENSATE PUMPS FOR THE MAIN STATION HEATING SYSTEM.

Mail Terminal and five exhaust fan rooms in pent houses on Head House roof and one exhaust fan room in central pent house on Mail Terminal. Steam is delivered at 125 lb. pressure to a steam distributing central header in the Head House south fan room, from which it is transmitted at the same pressure to low pressure headers in each of the two main fan rooms, the pressure being reduced by means of reducing valves before entrance to low pressure headers. Two heating mains are taken from each low pressure header, one for the indirect fan heaters, the other connecting to the direct radiation risers in the one half of the building. On account of the large public spaces and for architectural reasons, the building walls contain many offsets requiring corresponding offsets in risers and, in certain cases, auxiliary distributing horizontal mains over large spaces.

Fresh air is drawn from the roof through open fresh air shafts approximately 10x16 ft. to each of the two large fan rooms and exhausted through similar shafts to the roof. At the lower end of each fresh air shaft is a large suction chamber with connecting passages to each fan. At the entrance to each passage the air passes through a vertical bank of Reed air filters. These are in unit sections 18 in. x 18 in. x 4 in. deep and consist of a sheet metal frame with diamond mesh on front and back, enclosing oily steel wool. The units are removed each month, washed in hot soapy water, and dipped in oil, for which purpose special wash tanks and drip racks are provided. These filters were installed in place of air washers originally specified, after comparative tests and are proving very effective in the removal of dirt from the air. A total of 477 active units and 48 spares were furnished each with a capacity of 1,000 cu. ft. of air per min. In addition, three similar active and one spare units are used on suction to air compressors at the boiler house.

After passing the air filters, the air is tempered by American Radiator Co. indirect steam radiators and is drawn through the fan and then divided, part passing reheating coils, the remainder going through a by-pass. The proportion of tempered and the hotter reheated air is automatically controlled by mixing dampers at the entrance to each fresh air supply duct. A thermostat in the space served causes the damper to move so as to increase the percentage of reheated air if the room is too cold and vice versa; at the same time the total air supplied each duct is not changed. The temperature of the tempered and reheated air in the fan chambers is automatically controlled by thermostats operating steam supply valves to the heaters, picture on page 529. All thermostatic control apparatus of this nature, including switches for remote control of radiators in places difficult of access, was installed by the Johnson Service Co.

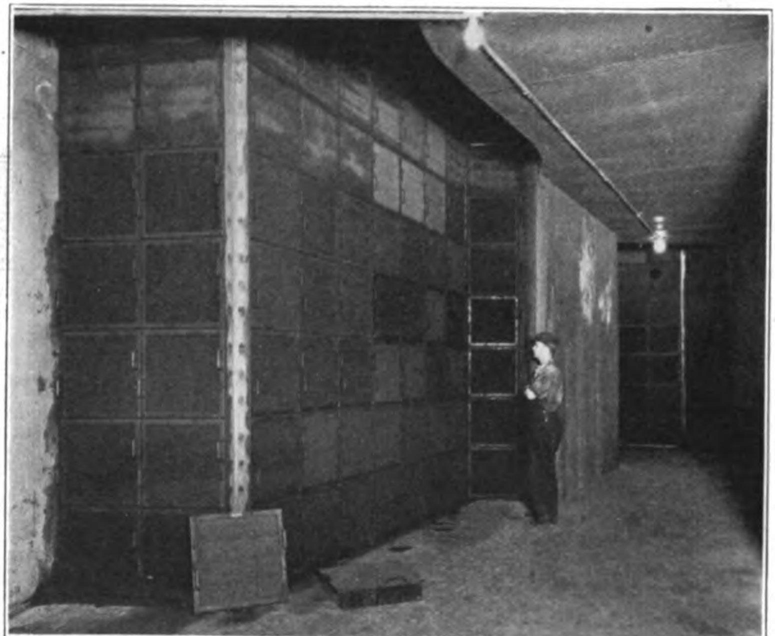
Used air is exhausted through an extensive duct system and vent shafts to fans in pent houses on the roof. Approximately one million pounds of iron, principally galvanized sheets, were used in ventilating ducts. There are 40 fans of the B. F. Sturtevant make with a combined capacity of one million cu. ft. of air per min. and with a motor load of 600 hp.

The Main Waiting Room, 100 ft. wide, 220 and 275 ft. long at floor level and above second floor balconies respectively, and 112 ft. to ceiling is an interior room, being completely surrounded by station facilities below and office floors above. Yet it is architecturally treated so that expanses of natural light appear in every direction and all the buoyant effect of an immense exterior room is attained. The flat arched ceiling contains a skylight 80 ft. by 180 ft. The east and west upper walls have large open plaster grills through which one looks directly to windows in the light court, similarly grills at the north and south open into naturally lighted office corridors, and in the lower portion of the building large windows in inner and outer walls of surrounding spaces give direct views of natural light.

In heating the room it was possible to treat it largely as an interior room, supplying heat at the points of heat loss supplementing a general ventilating and indirect heating arrangement. The unusually large skylight has its heat loss provided for locally by means of 5,250 sq. ft. of direct radiation in the form of pipe

coils along the cross girders and having the same curvature as the roof. Serious dripping from condensation would occur if the inner surface of the skylight were not heated. Back of the side wall plaster grills, are banks of radiators and similarly there are radiators in corridors opposite end wall grills. At the street and cab drive entrances, radiators are installed back of ornamental iron grills and fresh air is supplied from the ventilating system. The main source of fresh air supply to the room is 17,600 cu. ft. per min. which enters at floor level through four tectural conditions which made placing of radiators at otherwise desirable locations inadvisable. The principal heat loss, that of the north and south train gates, is taken care of by direct radiators in the space between outer and inner doors. The loss due to large glass area in the upper portion of building is counteracted by continuous banks of radiators on elevated ledges along the north and south walls.

The group of shops and offices at the east end of the Concourse have fresh air and exhaust systems. A mechanically cooled air circulating system is provided



INTAKE SIDE OF THE AIR FILTERS WHICH REMOVE ALL DIRT FROM THE AIR BEFORE IT GOES TO THE FANS.

large grills at ends of room and two smaller grills in west wall and which gives additional general heat. Entire freedom from visible direct radiators is accomplished in this room by special treatment as above and with uniform heating of the entire space. For convenience of operation, the skylight and all radiators not easily accessible are operated by remote control switches.

The concourse, shown on page 522, presented a difficult heating problem on account of its unusual exposure and archi- for the large show cases in which candies are displayed. In the basement mechanical ventilation is supplied to kitchen at east end and to offices and toilet rooms. The large public space at Concourse level and the Baggage Room in basement depend upon natural ventilation through the many doors and windows. The basement is only partially below the surrounding track level and the north and south walls contain 10x-10-ft. doors on baggage ramps for each pair of tracks. These doors remain open

in summer and are electrically opened and closed in winter for the passage of baggage trucks so as to avoid excessive admission of outside air.

Ventilation of the cab and baggage drive system presented a special problem in which, in as far as possible, direct openings to atmosphere have been provided, supplemented by fan supply and exhaust systems. The two 35-ft. cab drives adjacent to Adams St. and Jackson Blvd. have ceilings 45 ft. high and each has thirteen openings above street, 6 ft. wide by 12 ft. 8 in. high. The east walls of the cab stands are open and protected by iron bars which permit natural circulation of air and in addition 30,000 cu. ft. of air per min. is supplied through large wall grills and the entrances from cabstand to station have fresh warmed air supplied between outer and inner doors. The baggage drives adjacent to Adams St. and Jackson Blvd. have large openings in the ceiling, practically continuous, which are surrounded above sidewalk level by stone ballustrades. Similar but smaller openings extend from Clinton St. baggage drive to window ledges above, and from this drive and the central baggage drive and teaming concourse 80,000 cu. ft. per min. is exhausted through grills distributed along curb.

Locomotive Smoke Removal System

To prevent rebound of locomotive smoke from under surface or ceiling of Adams St. and Jackson Blvd. viaducts so as not to disturb passengers on platforms below and to keep smoke from drifting into the Concourse, special removal systems were installed in each viaduct. In order to arrive at a proper solution of this problem a test structure was built over an outlying railroad track. It was of wood and sheet iron but represented a full size viaduct bay at proper elevation above track and platforms. The general scheme is that of allowing the gases to pass into the space between road way and ceiling above the locomotive stack and then removing them by means of exhaust fans. The scheme was successful, but the actual installation was greatly modified in detail as a result of the experiments.

The opening above tracks is 36 in. wide and the ceiling is approximately 24 in. above top of locomotive stack. The smoke rises through converging baffles 2 ft. 6 in. high with 9-in. opening at top, at which point an inlet velocity of 220 ft. per min. is maintained by the fan. The viaducts are 66 ft. wide and each 44-ft. bay extends over two tracks. There are five compartments formed by girders at outer and inner sidewalk lines and center of street. Each of the three intermediate girders contains three 34-in. holes through steel web and concrete encasement, each hole being lined with a cast iron funnel for the passage of smoke and access of workmen. A round cast iron duct extends from the central opening in girder at middle of street to near the wall farthest removed from concourse. A 48-in. fan in the wall at this point removes smoke and discharges it above the train shed roof. Ilg Electric Ventilating Co. propeller type fans without housing and with ventilated motors directly connected and in the path of smoke were used. These are 2⅛-hp., 220-v., single phase, alternating current motors, without brushes and are remotely controlled from train gates. Eleven fans each with 20,000 cu. ft. per min. capacity and each serving two tracks are used.

Important features of this installation are as follows:

(a) A fan of this capacity serves two tracks almost as efficiently as one, as it is seldom that locomotives occupy adjacent tracks simultaneously and are both working hard. A single locomotive with heavy exhaust causes the smoke to enter the compartment and pass through the large holes and duct to fan, other portions of the system becoming balanced so as not to subtract from the fan capacity. In general, smoke does not come out of the opening over the adjacent track.

(b) The minimum effective velocity through the 9-in. opening above tracks is about 220 ft. per min. The desirable velocity is 300 ft. per min. but this is governed by size of smoke ducts and openings which can be had through the girders.

(c) Each compartment must be served by large openings as each must take the full locomotive exhaust.

(d) Baffles and ducts must be of durable materials, even cast iron deteriorat-

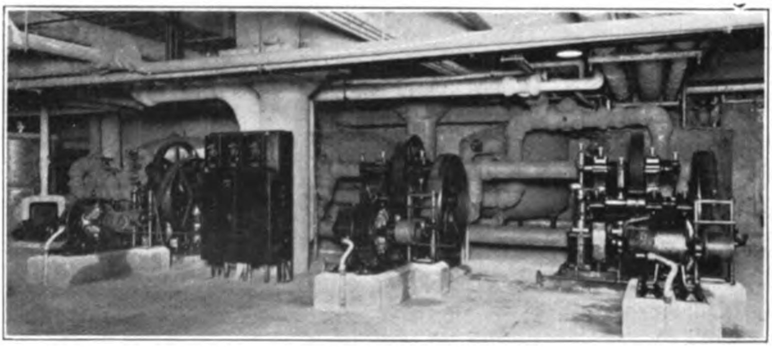
ing rapidly. For this reason, only one piece of duct is used per fan, this extending to center of street to equalize draft. Fan wheel and motor housing are of monel metal.

(e) This system removes most of the smoke and prevents rebound and annoyance to passengers and is efficient under the conditions at the Chicago Union Station.

Plumbing and Water Supply

Water is obtained from the city mains, the supply for the head house and concourse being drawn through 8-in. pipes from Adams St. and Jackson Blvd. to meters in the sub-basement. There is also a 10-in. supply to fire pumps from Clinton St. There is an 8-in. connection to the Harrison St. main which serves the Mail Terminal and an 8-in. connection to Power House from Canal St., these being cross connected so as to supply both buildings from either source if necessary. All water supplied to buildings is metered and filtered and is then divided, the street level and lower floors being directly on city pressure. Water for the upper floors is discharged to an open surge tank and pumped to house tanks on the roof from which it flows by gravity. See picture on page 535.

In the Head House sub-basement there are four filters and in the Mail Terminal one filter. Each filter has a capacity of 10,000 gal. per hr. and is of the pressure type using quartz as a filtering medium and alum as a coagulant; they were installed by the International Filter Co. There are three house pumps at the Head House and one at the Mail Terminal, each with a capacity of 10,000 gal. per hr. of the Worthington triplex motor driven type. Domestic hot water at the Head House is obtained through five Sims low pressure steam heaters, each with a capacity to heat 2000 gal. of water per hour from 50 deg. to 180 deg. F. and with a storage capacity of 500 gal. Two of these are on the low pressure service for lower floors, two in the high pressure service for the upper floors and the fifth is for kitchen service. All are interconnected. At the Main Terminal there are two similar heaters, each with a capacity to heat 2500 gal. of water per hour from 50 deg. to 180 deg. F. and with a storage capacity of 1000 gal.



HOUSE PUMPS CIRCULATE THE WATER FILTERED BY THE FILTERS IN THE BACKGROUND TO ALL PARTS OF THE HEADHOUSE.

The two principal public toilet rooms are in the Head House basement and are reached by stairs from the Women's Waiting Room and Barber Shop Lobby. The Women's free toilet contains 21 closets and 11 lavatories and the pay toilet, 9 closets and 18 combination closet-lavatories and four complete bathrooms. The Men's free toilet contains 38 closets, 18 urinals, 16 lavatories and one Bradley wash fountain and the pay toilet, also 26 closet-lavatories, four of which are provided with shower baths. The floor, walls and compartments are of Tennessee marble. In addition there are toilet rooms and lavatories on each of the office floors and in various portions of the buildings for use of the public and employees. The fixtures were furnished by the Standard Sanitary Mfg. Co. In general the lavatories are heavy vitreous china of the rectangular, rounded front type with or without integral back and with single

china leg. The water closets are heavy weight, vitreous china, syphon jet, wall hanging type with Sloan flush valves and "Never Split" ebony finish seats. The urinals are of the full interlocking floor type of heavy vitreous china. The bath tubs are of enameled iron with integral front to tile into the floor and into wall at ends and back and the janitors' sinks are 20x24 in. of enameled iron with roll rim and integral backs 12 in. high. All exposed fittings and piping are of white metal. West Disinfecting Co. liquid soap equipment is installed at lavatories in toilet rooms. Head House and Concourse fixtures include 563 lavatories, 312 water closets, 68 drinking fountains, 59 urinals, 80 slop sinks, 4 bath tubs, 19 shower baths and 5 Bradley wash fountains. The building plumbing was installed by O'Callaghan Brothers.

Ejectors and Building Drainage

Building roof drainage and waste from floors above street level are discharged by gravity to the city sewers or direct to the Chicago River, while drainage from the lower levels is discharged by means of ejectors. Soil and waste pipes and down spouts above ground are of wrought steel or galvanized iron pipe and below ground of extra heavy cast iron soil pipe. Below basement floors there is a separate surface drainage system of soft porous tile surrounded by broken stone to remove seepage water.

In the Head House and Concourse all low level drainage is delivered to one central group of ejectors installed in the sub-basement. There is one Shone type duplex pneumatic ejector, each receptacle having a capacity of 500 gal. per min. and one Yeomans Form A dry basin type, duplex centrifugal ejector, each unit of 500 gal. capacity, the total capacity being 2000 gal. per min. The pneumatic ejectors are at sub-basement floor level and normally handle the large amount of water from the kitchens and toilet rooms in basement. The centrifugal ejectors are in a concrete basin below sub-basement floor and handle the sub-basement and other deep level seepage and waste, but by means of a by-pass can relieve the pneumatic ejectors of the basement sewage. The combined equipment is of heavy construction and its location places it under the constant supervision of the engineer in the sub-basement, where its full capacity is available to handle unusual amounts of water occurring in any part of the lower levels. One duplex. motor driven centrifugal ejector, each unit having a capacity of 150 gal., per min., was installed at the Power House by the Chicago Pump Co., who also installed two similar units in the Mail Terminal.

Fire Protection Systems

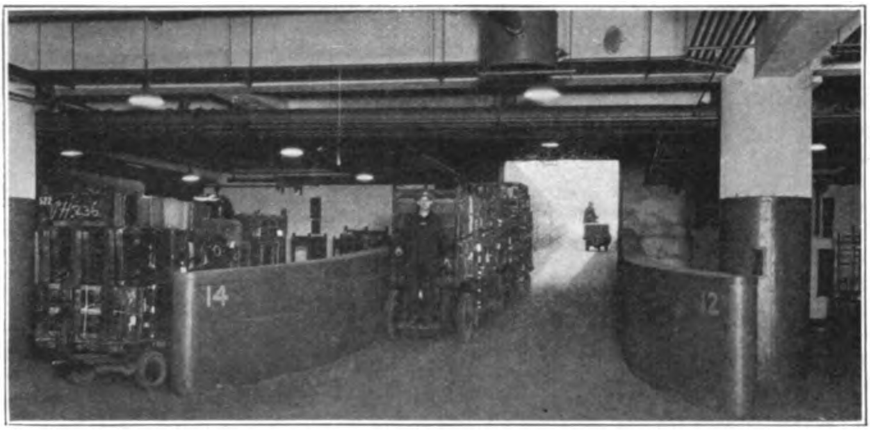
In the Head House sub-basement there is a Dayton-Dowd, 1500 g.p.m. Underwriters centrifugal fire pump, direct connected to a 250-hp., 440-v., 3-phase, alternating current motor. The controller is of the combined manual and automatic type and is actuated by a drop of pressure below a predetermined point in the 2000-gal. pressure tank. See page 545. Similar equipment of 1000 gal. per min is installed in the Mail Terminal. Distributing mains are at the basement ceiling with risers to all floors. Siamese steamer connections are provided at street level and similar fire boat connections at the dock wall for use of the City Fire Department. Nickel plated swinging hose racks are installed throughout the buildings with 1½-in. unlined linen fire hose for use of employees and 2½-in. separate connections for the City Fire Department: Except for the office floors, practically all space in the buildings is occupied twenty-four hours per day and, therefore, sprinkler systems are only provided in places of unusual hazard, such as incinerator room, waste paper storage and carpenter shop. Chemical extinguishers are provided throughout the buildings and chemical carts stationed in basement. Illinois District Telegraph Co. fire alarm is installed in Head House, Concourse and Mail Terminal.

Incinerator

A Morse-Boulger Destructor Co. incinerator 9 ft. 9 in. long, 8 ft. 6 in. wide and 8 ft. high, lined with first quality Pennsylvania fire clay blocks and guaranteed to burn 6 tons of mixed rubbish, waste paper and garbage per day is installed in the basement of Head House. It is located in an irregularly shaped room of approximately 600 sq. ft. area near the office freight elevator. Location of this

incinerator presented a serious problem as it did not seem possible to provide a suitable stack, but it was found that this could be placed in the exhaust vent shaft. The stack is 3 ft. in diameter, the lower portion of $\frac{3}{8}$-in. and upper portion of $\frac{5}{16}$-in. steel, 186 ft. high and lined with fire brick which rests on supporting angles. The stack is set on a substantial foundation and extends above the pent house roof.

A Chicago Incinerator Co. 2-ton capacity incinerator is installed in similar room on the sixth floor of the Mail Terminal. Both of these incinerators are used to dispose of the large amount of rubbish, soiled waste paper, etc., accumulating daily. Clean paper is baled and sold. Heavy garbage is hauled away.



RAMPS FROM THE BAGGAGE ROOM UNDER THE CONCOURSE TO THE TRACK LEVEL WERE A DECIDING FACTOR IN THE FUNDAMENTAL PLAN OF THE STATION.

Elevators

A total of 34 electric elevators was installed by the Otis Elevator Co., of which 13 are passenger and 21 freight. Provision is made for future elevators, particularly in the case of the Head House office building, where eight elevators are installed but provision made for twenty elevators to serve the building when extended to its full height. These elevators are of the electric, gearless, one-to-one, traction type, with 2500 lb. capacity and 600 ft. per min. speed.

At the Van Buren St. entrance to the Mail Terminal, there is a bank of three passenger elevators of the single worm gear, traction type, with 2500 lb. capacity and speed of 350 ft. per min. Most of the passenger elevators are driven by 34-hp. motors. Seventeen of the freight elevators have large platforms intended for baggage and mail trucks. These platforms vary in width from 6 ft. 6 in. to 7 ft. and in length from 16 ft. to 18 ft. Quite often elevators of this type have platforms either too narrow or too short for efficient handling of large loads of baggage or mail.

These machines have a capacity of 8,000 lb. and speeds of 100 ft. per min. for the low-rise elevators and 150 ft. per min. for the nine elevators running from basement to sixth floor of the Mail Terminal. They have an auxiliary micro drive by which the main motor is automatically cut out on approach to a landing and a smaller motor brings the platform at slower speed to exact floor level. The combined elevator motor rating is 1100 hp. The Otis Elevator Co., also supplied 5 electric dumb waiters with push button control.

Baggage Facilities

The baggage facilities represent a remarkable advance, the noticeable features of which are separate baggage platforms free of columns, substitution of ramps for elevators, a vast baggage room in one unit served by an extensive teaming con-

course, and the location of the checking counter at most advantageous point to serve the public. The Baggage Room 250-ft. x 280-ft. occupies the basement directly below the Passenger Concourse. The separate baggage platforms serving each pair of station tracks terminate in the baggage room, reaching this level by means of 6.75% ramps 10 ft. 4½ in. wide and 178 ft. long, of which 54 ft. is within the Baggage Room. The teaming concourse beneath Canal St. is 56 ft. wide, 400 ft. long, and extends along the west side of the Baggage Room which for a depth of 50 ft. is widened to 400 ft. Entrance to the teaming concourse is by means of the 40-ft. central drive extending west to Clinton St. where it divides into two 20-ft. drives leading to the Adams St. and Jackson Blvd. cab drives. The American Express Co. occupies the south 90 ft. of loading platform to a depth of 50 ft.

The Baggage Checking Counter at Concourse level is 35 ft. wide, 55 ft. long, and directly over the baggage loading platform and both this and a separate enclosure of the same size for parcel checking are located in Canal St. space midway between the cab stands, ticket office and train gates. The baggage checking enclosure contains heavy steel shelving divided into 125 compartments, each 15 in. deep, 27 to 30 in. high, and 4 ft. to 5 ft. long for all incoming and outgoing hand baggage. The parcel checking counter has 396 compartments, the typical size being 20 in. deep x 20 in. high by 4 ft. 6 in. long. There are additional racks for golf clubs, umbrellas and coats. There is storage capacity for 3000 parcels and 4500 have been checked in one day. An Irving steel grating midway between floor and ceiling is provided for attendants at upper shelves when unusual business requires their use.

Approximately 5000 pieces of passenger baggage are handled each day and in addition large quantities of newspapers, railway mail and railway supplies. Incoming baggage is unloaded from trains upon electric burden-carrying trucks or upon trailers pulled by electric tractors and the average running time from train, down the ramp and to point of unloading is approximately one minute. Hand baggage on a separate truck is run direct to checking counter elevator and placed in racks often in advance of passenger arriving on same train. Trunks are deposited on floor near loading platform until called for.

Outgoing baggage is received from street trucks at loading platform, weighed, and deposited in outgoing section according to serial number of transfer check. A checking slip is made out giving weight, name of transfer company, serial number, etc., and sent by pneumatic tube to checking counter where it is filed. On arrival of passenger with claim check information is available to check baggage without delay and a duplicate check is dispatched to "stripping counter" in baggage room and an attendant locates the baggage, attaches check and places trunk on a truck assigned to the proper outgoing train. Outgoing hand baggage delivered by passenger at checking counter is checked, delivered to baggage room by means of elevator or spiral chute and placed on truck for next departing train.

Railroad Mail Room

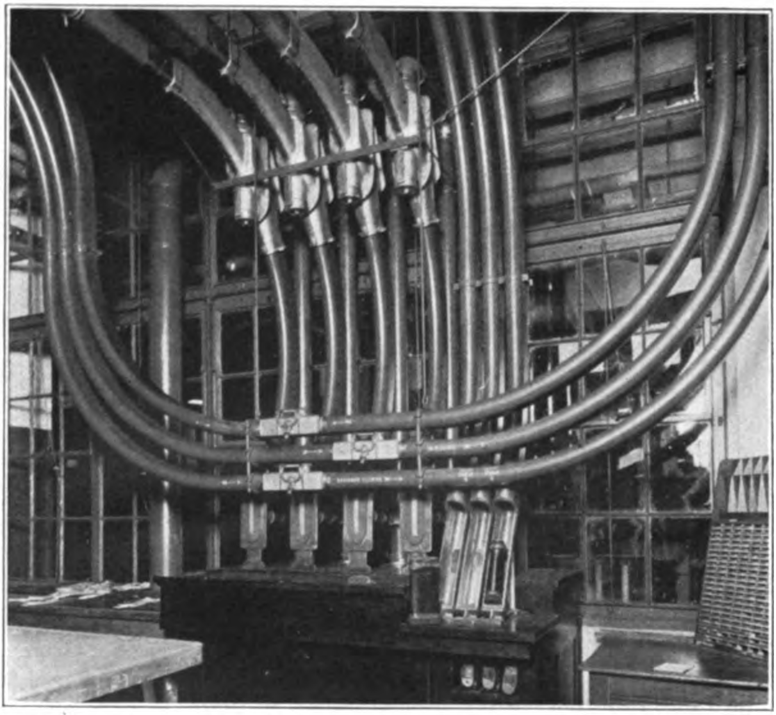
A space 25 x 52 ft. at northwest corner of baggage room and near loading platform is separately enclosed for handling railroad mail or railroad companies' letters and parcels sent in baggage cars. The space includes a small office for records and registered mail and a lavatory and locker room. The remaining area contains steel sorting cases for incoming mail forming the west wall with 51 compartments ranging in size from 12x12x16 in. to 24x20x24 in., open on the inside and provided with locked doors on the outside, similar cases for outgoing mail along the north wall with 79 compartments ranging in size from 6x6x18 in. to 24x24x18 in., five steel partitioned stalls 5x8 ft. with 2-ft. shelf 4 ft. above floor along east wall for storage of bulky material, each stall assigned to a separate railroad company, receiving window and table, sorting tables and pouch racks.

Baggage Handling Equipment

The provision to be made for handling of baggage involved not only the type and quantity of apparatus but also affected the design of the station itself.

Separate baggage platforms required either an elevator for each platform, a ramp, or an escalator designed for handling trucks. The desirability of avoiding a general elevator scheme was seen on account of high first cost, repairs and maintenance and delay in operation, also failure of one elevator meant temporary loss of two tracks. Escalators with 10% or more incline were considered, these to have moving central chain with projecting hooks to pull trucks along. They were discarded as expensive to install and operate, not commercially developed and liable to failure and accident.

Careful study was made of ramps elsewhere, tests were made on an 8.25% ramp, and calculations made of weight of loads, resistance, speed, electric current required, etc. On conclusion of this investigation it was recommended that electric equipment could operate and brake satisfactorily, economically and safely on a 7% ramp and that such operation was much to be preferred to elevators or escalators. As a result ramps of 6.75% grade, 178 ft. long were installed and are now in service with very gratifying results. It had been expected that a tractor with heavy trailer loads could operate successfully on ramps but operation has shown that a loaded burden carrying truck can pull one trailer load on these ramps. On actual test a burden carrying truck was loaded with 3280 lb. pulling a trailer weighing 850 lb. and loaded with 2100 lb., gross weight 9830 lb., made 33 round trips of .4 miles up and down ramps and along baggage platform on one battery charge. The loading was determined by first placing 36 trunks on a truck and trailer to a height of 7 ft. 6 in. and then taking the equivalent in other materials. In comparison a tractor with two trailers and same net load made 48 round trips and battery was not exhausted until second day.



PNEUMATIC TUBE CENTER THROUGH WHICH ALL BAGGAGE CHECKS ARE HANDLED.

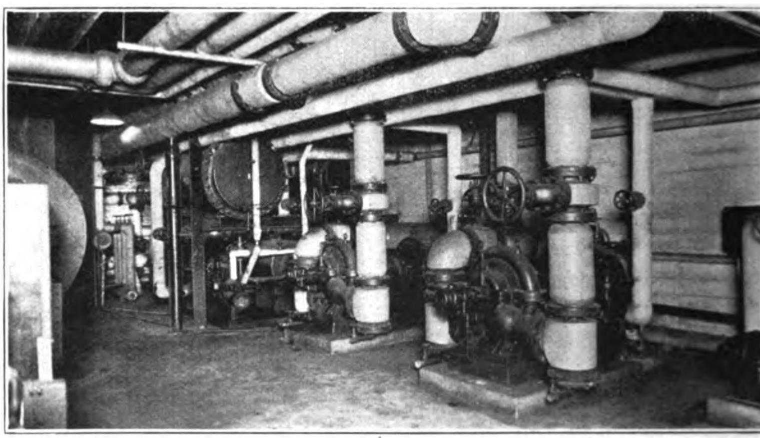
The committee on baggage equipment

recommended that gasoline tractors formerly in use be disposed of, that electric tractors be retained and others purchased and that eight burden carrying trucks and 50 special baggage trailers be purchased. Gasoline tractors were eliminated on account of noise, poisonous fumes, greater turning radius and operating cost sufficient to offset lower first cost. Tractor and trailer operation was recommended for heavily loaded trains as it permitted advance loading of outgoing baggage and did not require immediate unloading. Burden carrying trucks were recommended particularly for use on those platforms on which it had been necessary to install elevators instead of ramps and for single loads.

tongue when thrown in a vertical position is automatically locked, thereby permitting the truck to be drawn from the opposite end. The trucks purchased from the Highway Trailer Co., hold 15 to 20 trunks and are exceptionally well designed and constructed and represent a distinct advance in baggage equipment. Consideration of steel, wood and rubber wheels and tires resulted in the adoption of the latter, due to freedom from noise and protection to platforms, although they pull harder than steel tires.

List of baggage and mail tractors and trucks:

Seven Elwell Parker type DG drop frame, burden carrying electric baggage trucks, spur gear drive, four wheel steer.



CENTRIFUGAL PUMPS WHICH CIRCULATE HOT WATER FOR HEATING THE MAIL BUILDING. HEATERS IN THE BACKGROUND.

Of available types of trailers the castor type with fixed rear and swivel front wheels was eliminated as the latter caused truck to be drawn towards and to damage cars in loading, also it required turning around on the platform. The four wheel steering trailer movement in a fixed arc of a circle caused damage to cars and they could not be handled by hand. The wagon-type truck with tongue, so long used in baggage work had but one serious fault, namely that it required turning on the platforms.

After tests of experimental trucks and consideration of various types, it was decided to adopt a baggage truck with tongue at each end so arranged that the

double end control, capacity 20 to 25 trunks, platform 43½ in. wide, 136¾ in. long, 11¼ in. and 33¼ in. high.

One Elwell Parker type TC burden carrying electric baggage truck, spur gear drive, four wheel steer, single end control, platform 40 in. wide x 92¾ in. long x 12 in. high.

Seven Elwell Parker type TL electric tractors, 2 with worm drive and dual front wheels and 5 with spur gears and single front wheels.

Five Mercury type H electric tractors, bevel and planetary gear drive, twin front wheels.

Three Hundred Mercury caster type mail trailers, platform 42 in. wide, 7 ft.

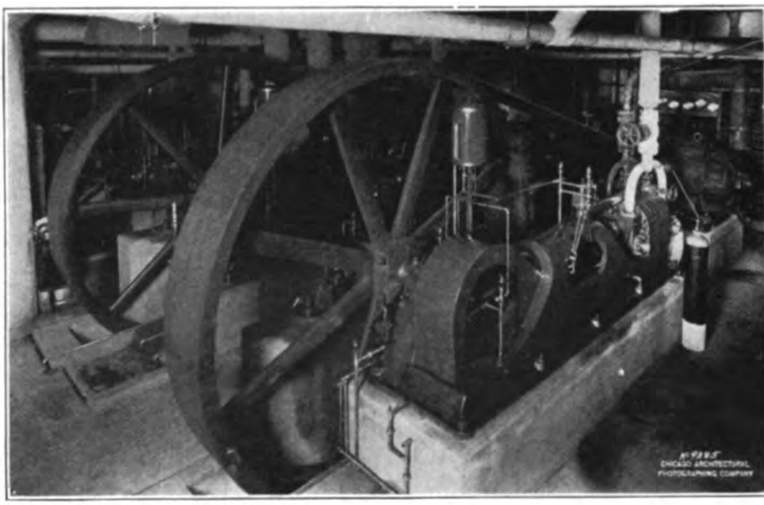
long, 14 in. high, steel end racks and frame, with Hyatt roller bearings.

Fifty Highway Trailer Co. baggage trailers of special double "fifth wheel" type with tongue at each end, platform 42 in. wide, 9 ft. 4 in. long, 21 in. high, end racks 5 ft. above platform, 16 in. rubber tired wheels, Timken roller bearings.

Twelve Guilford S. Wood 24 in. x 5 ft. welded pipe baggage hand truck, Hyatt roller bearings.

One Colson 20 in. x 56 in. steel hand truck, rubber tires and ball bearings.

Nine Haskins special caster type ushers trucks, platform 30 in. x 5 ft. x 22 in. above floor, steel clad body 15 in. deep at sides, 22 in. at ends, Colson ball bearing rubber tired wheels.



TWO OF THE REFRIGERATING MACHINES INSTALLED IN THE HEAD-HOUSE BASEMENT.

Five Preston special caster type ushers trucks welded pipe frame body 26x53 in. lower deck 7 in. above floor, steel mesh enclosure at ends, upper deck 29 in. above floor with 9½-in. enclosure at ends and sides, golf bag pocket 13x26x22 in. steel mesh enclosure.

Note:—The above list does not include old equipment to be disposed of, which will require additional new equipment.

Pneumatic Tube Systems

There are two pneumatic tube systems in the Head House and Concourse, one installed by the Lamson Company and the other by the Pneumatic Tube Supply Co., the latter operated by the Western Union Telegraph Co. This system transmits messages between the public telegraph offices in the station, the Western Union Telegraph Company building and other offices of that company, the ticket reservation room, the baggage clerk's office, and the telegraph offices of the Chicago Union Station Co. and the Pennsylvania, the Burlington and the Milwaukee, and other railroad companies. Handling of messages in this manner by a public utility company both for itself and other companies represents a new type of service rendered to the public.

The system is of the vacuum pressure circulating loop type with 2¼-in. tubes. There is a central relay room in the basement, at which point the incoming carriers drop on the upper run of a belt conveyor and are delivered to an attendant who relays the messages in the same or other carriers by means of the lower run of the conveyor on which guides direct them to the sending terminals where they are forwarded by another attendant. There are 13 sending terminals of which that to the telegraph company's main office is automatically fed and timed so as to avoid interference of carriers. Over 500 carriers are handled per hour. The relay room contains two Worthington motor driven, single stage 17x14-in. air

compressors, with promise for a third compressor and auxiliary equipment.

The other system is of the Lamson vacuum type with 3x6-in. oval tubes and it is driven by Spencer centrifugal type blowers in duplicate, direct connected to 10-hp. motors arranged with automatic control so that in case one of the motors is overloaded the other will come into service.

This system serves the baggage department and the sleeping car reservation room, delivering sleeping car diagrams from this room on the third floor to the passenger agent's office near the train gates before depature of each train. The baggage department work consists of dispatching weigh checks from scales at two points on the baggage loading platform to the baggage check counter on floor above and transmitting these and other baggage checks and papers between the checking counter, the exchange desk in baggage room, the baggage clerks, the baggage master and the inbound baggage center. A view of the pneumatic tube terminals at exchange desk is shown in the picture on page 539.

Mechanical Repair Shop

In the north half of Head House basement there is a space 80x100 ft. assigned to carpenter shop, pipe and machine shop, electricians, elevator repairs, office, toilet and locker room. An adjoining space 40x40 ft. is assigned to paint shop, paint storage vault and marble shop. The greater portion of the repair work to buildings and equipment will be centered here, although there are smaller spaces devoted to repairs in the Mail Terminal, concession space, etc. These shops are fully equipped with benches, tools, etc. for the efficient handling of all kinds of repair and revision work, some of the larger equipment being as follows:

Machine, Pipe Shop and Electrical Shop

1 Boye and Emmes 18 in. x 10 ft. engine lathe
1 Columbia Machine Tool Co. 20-in. shaper
1 Superior 25-in. drill
2 Washburn 14-in. sensitive drills
1 12 in. x 2 in. double floor grinder
2 8 in. x 3/4 in. double floor grinders
1 Racine 8 in. x 8 in. high speed metal saw
1 Oster 1½ in. to 6 in. pipe machine

Carpenter Shop

1 Oliver 14 in. saw table with mortising and boring attachment
1 Oliver 30 in. band saw
1 Oliver 16 in. hand planer and jointer
1 Oliver combination tool grinder
1 American floor sander
1 Clarke floor and hand sander
Work benches, lumber storage, etc.

Store Rooms

Supplies to the Head House will be delivered at central baggage drive in basement, a back-in space and unloading platform sufficiently wide and deep to receive two trucks being provided on the south to serve kitchen and concessions, and on the north to serve the passenger terminal and office. East of the latter is a waste paper and bulk material storage room 20x30 ft. and west of it is the receiving and general storage space approximately 55 ft. wide with an average depth of 45 ft. Adjacent to the general storage is a janitors' storage room 30x30 ft. and janitors' closets are provided throughout the building. Track supplies and materials received in carload lots will be stored at Canal and Harrison Sts.

Refrigeration System

In connection with the extensive kitchens, dining rooms and soda fountains, there is a total of seventy mechanically cooled refrigerators ranging in size from the commissary storage 33 ft. 10 in. long by 15 ft. 10 in. wide and divided into various sections to comparatively small units for special purposes. The larger storage refrigerators were built on the premises by the Union Insulating and Construction Co. In general, the exterior walls of these refrigerators are 7 in. thick consisting of 5 in. of pure sheet cork board finished inside and outside with 1 in. coating of Portland cement; interior walls similar except that cork insulation is 4 in. thick. All refrigerators are equipped with coils for circulation of cooled brine which necessitates a brine circulating system throughout the entire building area.

In addition, there is a cooled drinking water system serving over 100 public drinking fountains and faucets at lunch

counters and soda fountains. Five drinking fountains are located in the corridors on each office floor and others are conveniently located in public rooms and work spaces.

The refrigerating plant located in subbasement of Head House was installed by the American Carbonic Machinery Co. See picture on page 541. It is of the motor driven, compression type using carbon dioxide as a cooling gas. The apparatus consists of two 70-ton compressors, each with 100 hp. motors for general refrigeration, one 20-ton compressor with 30-hp. motor for cooling of drinking water, duplicate, motor-driven centrifugal pumps for circulation of brine, drinking water and condenser water, brine cooling and water cooling tanks and carbon dioxide condenser. A separate drinking water compressor is used as this service constitutes a fairly large load which does not require as low temperature as the general refrigeration, the latter being especially low to enable brine circulation to cool ice cream throughout the building and to maintain zero temperature by direct expansion in sharp freezer. One of the large compressors is usually sufficient for the general refrigerating load, but both may be operated at one time if required. An unusual feature is that of condenser water circulating pumps which take suction from the building supply main and return it to the same main beyond a check valve. In this way by using a very small amount of power, the entire building water is available at condensers. If condenser water were discharged to the surge tank and pumped to house tanks to serve the upper floors, the large quantity of water used under city pressure in low level public spaces would not be available for condenser use. A thermostatic by-pass is set to open in case the condenser water rises above a safe temperature, but rarely does so, indicating that practically no water is wasted.

At the Mail Terminal there is a 7½-ton drinking water cooling plant also installed by the American Carbonic Machinery Co.

Electrical Equipment in the Chicago Union Station

By Clifford W. Post*

Presented October 5, 1925

Continuity of service is to be desired above all things in a station such as this. So much depends upon the electrical apparatus that every precaution is taken to insure that there will be no interruption to any of the services. The decision to purchase power rather than to install a private plant was made only after a most careful study of all the facts and possibilities. This paper describes the equipment installed and several unusual services which required special treatment.—Editor.

THE electrical features of the station cover many kinds of electrical service and applications. They include a high tension substation with its transforming and converting equipment, underground distribution system, building lighting, street lighting, power for heating and motors, telephones, telegraph, telautograph, clocks, time stamps, time recorders, fire alarm, train lighting, battery charging and baggage and mail handling by electric truck and tractor. It represents an expenditure of $1,500,000.

Electrical Substation

Electric power for the entire project is supplied by the Commonwealth Edison Co., at 12,000 volts, 3 phase, 60 cycles necessitating a rather elaborate substation which is located in the sub-basement near the center of the Headhouse. The electrical equipment for the substation, including its installation, cost approximately $165,000. A similar substation was installed in the Mail Terminal Building at a cost of $133,600.

The equipment was largely furnished by the Allis-Chalmers Mfg. Co., the General Electric Co., the Cutter Electrical

* Electrical Engineer, Chicago Union Station Co.

& Mfg. Co., and the Condit Electric & Mfg. Co., and was installed by the Hatfield Electric Co.

The electric power is supplied by three 3-phase, 60-cycle, 12,000-volt lines. One of these lines comes direct from a generating station and the other two form a part of a loop connecting two or three other customers' substations, of which the Mail Building substation is one.

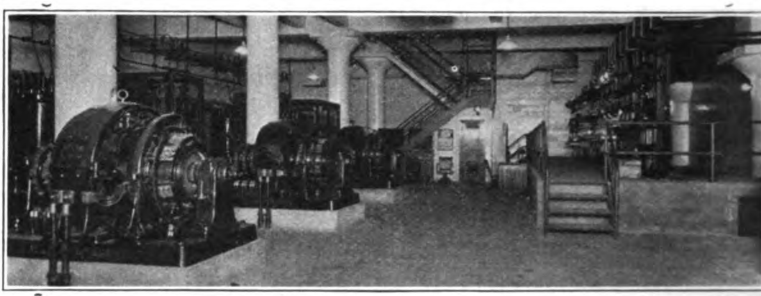
The 12,000 volt portion of the substation is in three distinct sections, separated by fire walls and doors, one line feeding each section. This will prevent any trouble occurring in one section from being communicated to the other sections. Spare units are provided for all services and connected to the different sections so that the entire station can be operated from any two sections and a large part from any one section. The Commonwealth Edison Co.'s lines are brought in at different points and brought through the streets over different routes.

The structure in which the 12,000 volt equipment is installed is arranged to isolate the lines, busses and circuits as far as possible by means of concrete and asbestos board barriers. The oil switches are installed in three separate rooms with concrete barriers between the switches. In the wall at the rear of each oil switch an opening about 4x4 ft., was left in the concrete structure which has been closed up with a single course of brick surrounded by a felt pad. This might be called a safety valve to relieve the pressure in case of an oil switch explosion, preventing the wrecking of the structure.

All 12,000-volt oil switches were furnished by the Condit Electric & Mfg. Co. Type F-11 switches are used for the Commonwealth Edison Co., lines and Type D-17 for the feeders.

The Commonwealth Edison Co.'s lines are connected to a separate bus from the feeder circuits. This bus is in three sections tied together with disconnecting switches. It will ordinarily operate as one continuous bus but can be separated in case of trouble or for cleaning or repair work.

This bus forms a part of the customers' loop when the loop lines are used. In addition to this bus a station feeder bus is installed in each of the three sections. Metering current transformers are installed between the line bus and each of these feeder busses. This arrangement was necessary in order to permit of an interchange of current between the Commonwealth Edison Co.'s lines without interfering with the metering of the station service.



GENERAL VIEW OF SUBSTATION SHOWING MAIN SWITCHBOARD AT RIGHT.

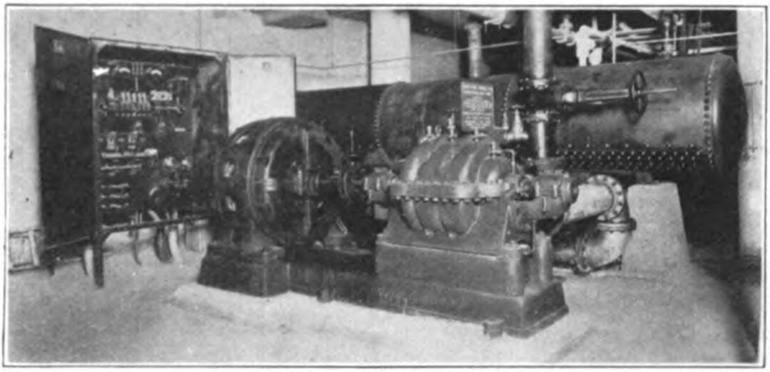
The feeders from the three feeder bus sections connect to the following:

Section No. 1
- 1 600-KVA, 3-phase, 60-cycle transformer for rotary converter.
- 1 833-KVA single-phase lighting transformer.
- 1 250-KVA single-phase transformer for 2300 volt service.

Section No. 2
- 1 600-KVA, 3-phase, 60-cycle transformer for rotary converter.
- 1 833-KVA, single-phase lighting transformer,
- 1 250-KVA, 3-phase transformer for fire pump.

Section No. 3—Same as No. 1.

This gives a total capacity of 4750 KVA, all of which is now installed ex-



CENTRIFUGAL FIRE PUMP WITH MOTOR, AUTOMATIC CONTROL PANEL AND PRESSURE TANK.

cept one of the 833 KVA lighting transformers.

There is at present a connected power load of 1700 hp. and a lighting load of 1000 kw. The building is designed for twelve additional floors. When this is completed, the power load will be increased to 2200 hp. and the lighting load to 1500 kw.

It is estimated the maximum load will be as follows:

230-V., D. C. Power, 800 kw.

115/230-V., A. C. building lighting 800 kw.

2300-V. Service, 200 kw.

The Mail Terminal Substation has a maximum load as follows:

230-V., D. C. Power, 300 kw.

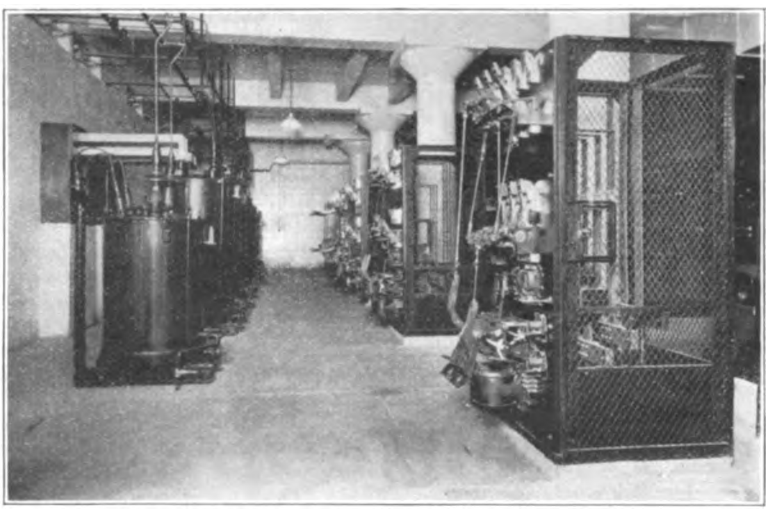
115/230-V., A. C. bldg. lighting, 450 kw.

440-V., A. C. Power, 150 kw.

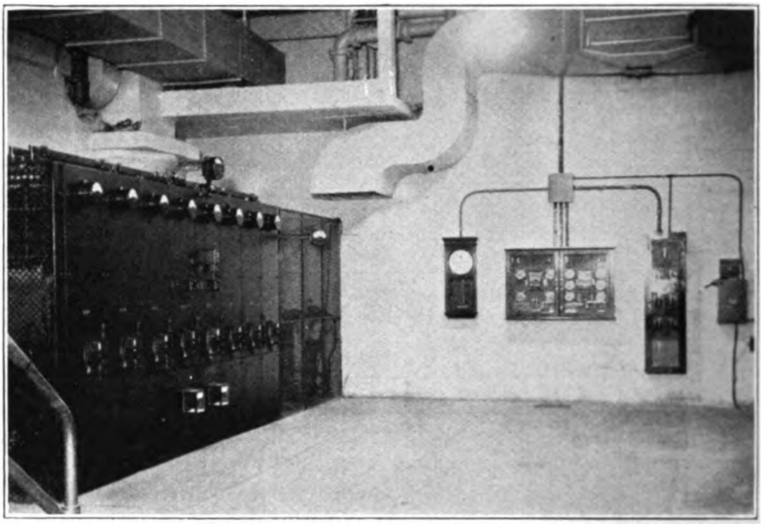
This gives a combined load as follows:

230-V., D. C. Power	1100 K.W.
115/230-V., A. C. bldg. lighting	1250 K.W.
2300-V. Service	200 K.W.
440-V., A. C. Power	150 K.W.
Total	2700 K.W.

The actual measured demand may not be this high since the peaks of the four services may not occur at the same time.



TRANSFORMERS AND CIRCUIT BREAKERS FOR MAIN POWER SUPPLY. STARTING BREAKERS FOR ROTARY CONVERTERS IN RIGHT FOREGROUND.



2300-VOLT SWITCHBOARD AND CONTROL FOR ALL TIME SYSTEM APPARATUS.

Consideration of speed control requirements of most of the motor applications in the main station led to the installation of direct current equipment for power purposes. This equipment consists of three 500-kw., 230-V. Allis-Chalmers Mfg. Co.'s rotary converters. The D. C. side of each of these rotaries is connected to a common bus to which all power feeders are connected.

The rotary converters are started from the A. C. end by means of half taps on the secondaries of the transformers and starting and running I. T. E. circuit breaker operated by a duplex motor mechanism. The two elements are electrically and mechanically interlocked so as to insure proper sequence of operation. They are equipped with an induction relay which prevents closing the running breaker until the rotary is approximately up to synchronous speed. The machines are controlled entirely from the main switchboard but the breakers can be operated by hand if necessary.

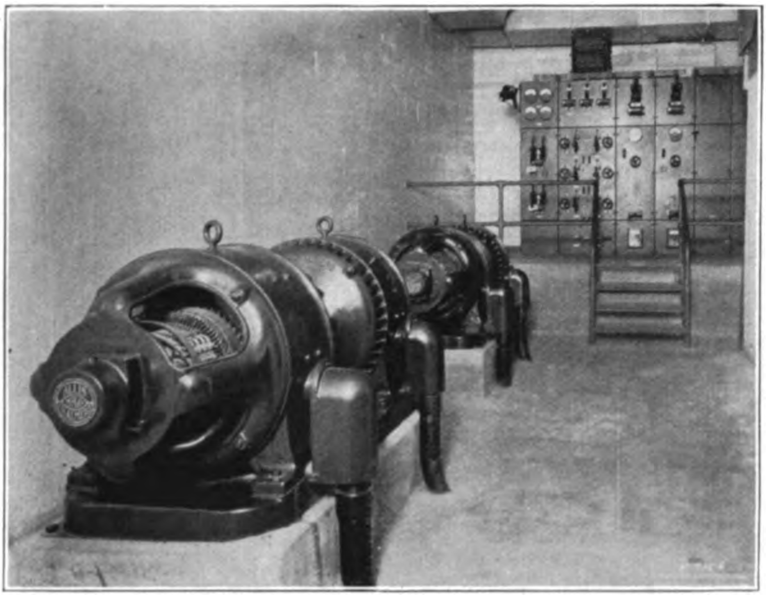
It will be noted from the illustration that these machines, as well as the main switchboard are raised above the floor level. The substation floor is the lowest part of the building and is 24 feet below the river level. The drainage of the sub-basement is handled by two 500-gal.-per-minute bilge pumps driven by 15-hp. motors. This should be ample for any emergency but the raising of the equipment above the floor was an additional precaution to prevent a shut-down on account of flooding the floor. All equipment can be operated with 18 inches of water over the entire floor. The raising of the main switchboard also provides convenient means for cable connections and a flexibility for the changing of cables and the installation of new ones.

Lighting System

The lighting for the station is supplied by three 833-KVA, single-phase, 12000/230 V. transformers connected to the three different phases of the 12,000-V. busses.

The secondaries of these transformers are controlled by 4000-amp. Type L. G. Cutter motor-operated, circuit breakers controlled from the main switchboard. There are four of these breakers mounted on two panels located between the transformers and the main switchboard.

These breakers are arranged in two rows; one in the top row controls Transformer No. 1 and the other Transformer No. 3. The two in the bottom row control Transformer No. 2. On account of the transformers being connected to different phases, they cannot be paralleled on the low side. These breakers are mechanically and electrically interlocked to prevent this.



SPECIAL MOTOR GENERATORS AND SWITCHBOARD FOR TRAIN LIGHTING AND BATTERY CHARGING.

This condition made it necessary to install two separate lighting busses on the rear of the main switchboard. The lighting feeder circuits are arranged in three horizontal rows. The bottom row is connected to one of these busses, the middle row to the other and the top row can be connected to either. Both busses are carried across the top and drilled for jumper connections for each feeder in the top row. By this arrangement the top row of feeders can be changed from one bus to the other as necessary to equalize the load on the two busses. Normally Transformer No. 1 will feed one section and Transformer No. 3 will feed the other section. Transformer No. 2 will be held in reserve and can be used in place of either No. 1 or No. 3. Also when the load is light, transformer No. 2 can be connected to both busses.

Oil circuit breakers were considered for this installation, but the decision in favor of carbon break circuit breakers was based on the following:

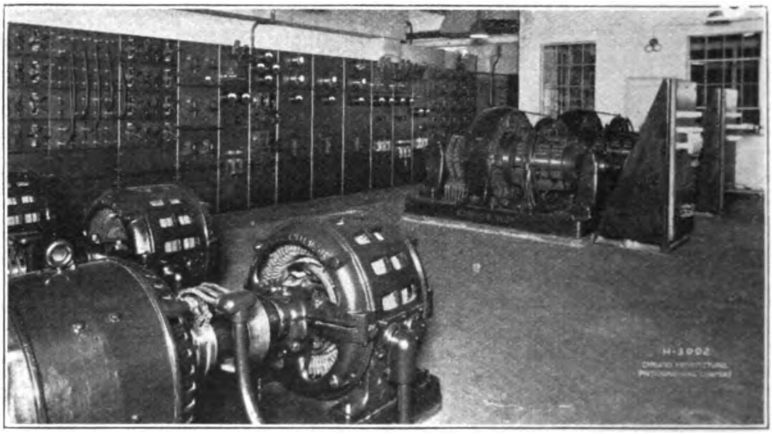
Carbon break circuit breakers require much less space and permit a much neater and more economical bus arrangement. For this reason they are usually mounted in conspicuous places under constant supervision of the attendant.

Oil circuit breakers are generally located in less conspicuous and less accessible places which adds to their inherent inaccessibility for inspection, repairs and cleaning. The inspection of oil switch contacts necessitates the lowering of the tanks. This is quite a problem especially with tanks of this size which requires a great deal of time and often long interruptions of the service. On account of this difficulty, proper inspection is often neglected. Any safety feature which is not properly inspected and kept in working order may become a hazard.

Under normal operating conditions the oil becomes carbonized and often collects moisture necessitating regular testing and occasional replacing.

On account of the arc being confined in a small tank, it is not uncommon for a tank to explode if the switch opens under severe conditions, causing considerable damage and often starting a fire.

There is some disagreement regarding the comparative rupturing capacity of carbon break circuit breakers and oil circuit breakers, but the writer's experience leads to the conclusion that for low voltage service a properly constructed carbon break circuit breaker will handle any in-



SUBSTATION IN MAIL TERMINAL. CHARGING BOARD FOR ALL TRUCKS USED IN THE STATION SHOWN AT THE REAR.

terruption as safely as an oil circuit breaker.

Main Switchboard Built by General Electric Company

All high tension and low tension equipment is controlled from this board except the 2300-V. service. The meters, relays and control for the Commonwealth Edison Co.'s lines are located on two panels at the right hand end of the board. The watt-hour meters, graphic meters and overload relays are mounted on this board. The equipment for lighting of trains and charging of car batteries is controlled from this board. There are also three blank panels for future lighting feeders to supply the 12 additional floors, for which the building is designed. All light and power feeders are fed from this board. Each feeder is connected to its bus through an I. T. E. circuit breaker which is non-closable on overload. In case the operator attempts to close a breaker on a feeder having a short circuit or an excessive overload, it will trip free from the handle and cannot be forced into the closed position. Type LL is used for all power feeders and for the lighting feeders above 400-A capacity. Type W is used for the smaller lighting feeders. The use of circuit breakers for the feeder circuits instead of knife switches and fuses permits of a very neat and accessible arrangement of busses and cable connections at rear of board. It also prevents the delays and inconveniences incident to the blowing and replacing of fuses, and provides a far more accurate and reliable protection.

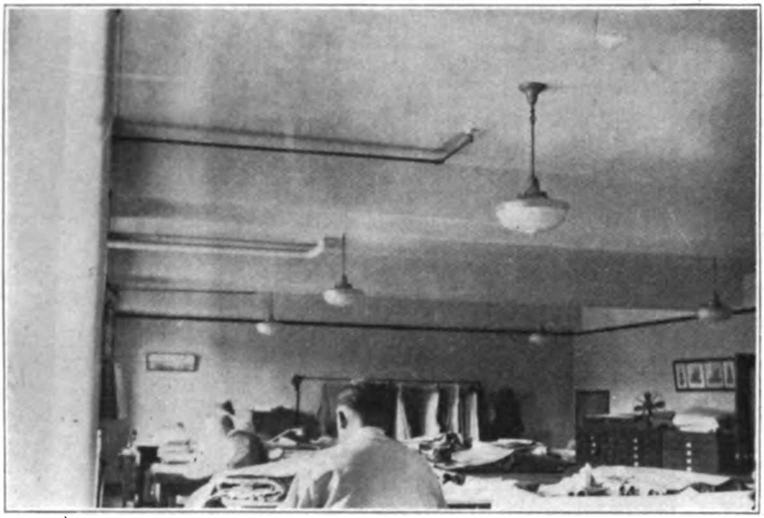
The lighting busses and feeders leaving the board are 2-wire, 230-V. At the base of each riser or point at which first tap is made an auto-transformer is installed. This is connected across the 230-V. feeder and the middle tap brought out for the neutral which is carried along with the outside legs to the end of this feeder, which provides 115/230-V. distribution. On account of the long feeder runs, this system effected a considerable saving in copper.

The cables are carried from the switchboard through a cable vault below and enter the underground duct system. These ducts run to the base of the risers at the four corners of the Headhouse, also to the Concourse and other distributing points.

All cables in the substation between transformers, rotary converters and switchboards are carried in iron conduit laid in the floor. All this cable as well as that in underground ducts is rubber insulated, lead covered. All wire used throughout the building has 30% rubber insulation.

2300-V. Switchboard

This board is supplied by two 250-KVA, single-phase transformers and was built by the General Electric Co. The transformer secondaries and feeder circuits are controlled by G. E. FK-13 hand



TYPICAL LIGHTING AS INSTALLED IN ALL OFFICES.

operated oil switches mounted on rear of board. The transformer switches are located at the center of the board and three feeder circuits on each side. The bus is installed at the top of the board with a set of disconnecting switches in the center between the transformer switches. These transformers are connected to the same phase of the 12,000-volt bus so that they can be paralleled on this board or used separately as desired. This board has two feeders supplying the interlocking system, two supplying the street lighting and two supplying the trainshed lighting. One of each of these feeders is connected to each section of the bus. It is intended that one of the transformers will carry the entire load leaving the others as a reserve.

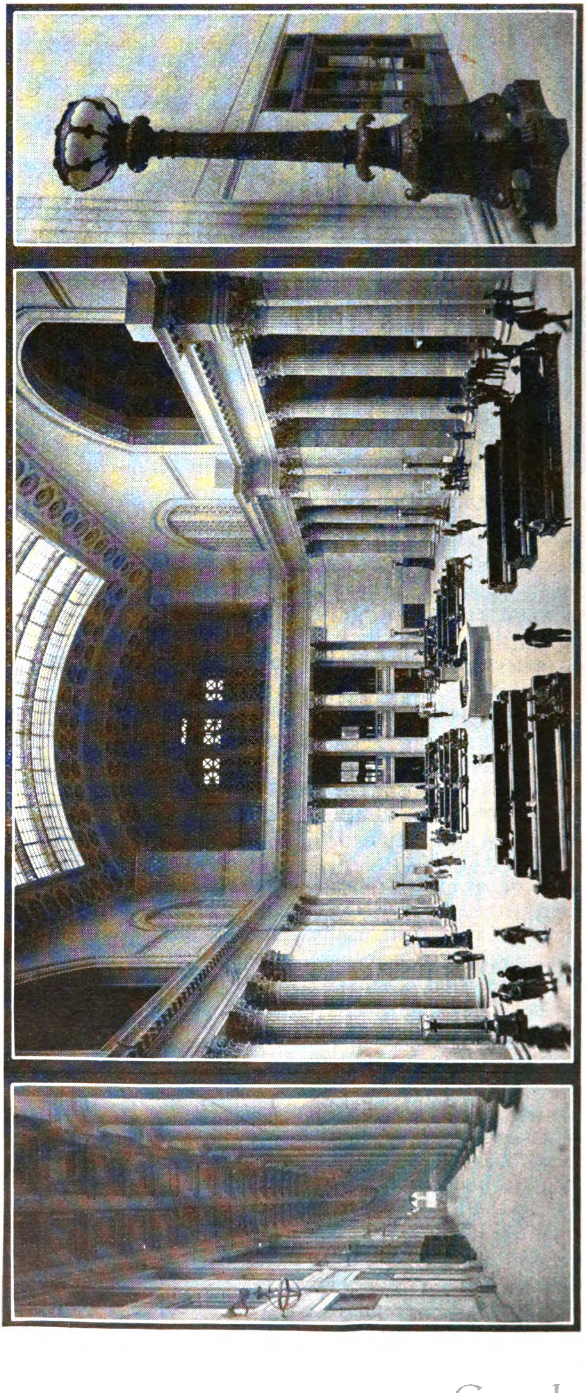
The two feeders for the interlocking system are in duplicate throughout the system, feeding duplicate transformers at various locations along the tracks. The feeders for the street lighting and the trainshed lighting are connected to alternate lights. By this arrangement the failure of one feeder will affect alternate lights only, leaving one-half of the lights burning over the entire space. This also permits turning off half of the street lights during the latter part of the night.

Disconnecting switches are installed between the bus and each oil switch. On the feeder side of each oil switch is a disconnecting pot head. This arrangement has a double purpose—first the complete disconnection of the oil switch in case it requires attention, and second a convenient method of grounding each transformer and feeder cable. This is accomplished by having a ground cable permanently installed at rear of board with pothead caps that can be inserted in pothead when regular caps are removed. All cables from this board are carried in underground ducts to the points of distribution. These ducts are entirely separate from the low voltage light and power ducts. These cables are also rubber insulated, lead covered, with the exception that Kerite cable is used for the interlocking feeders.

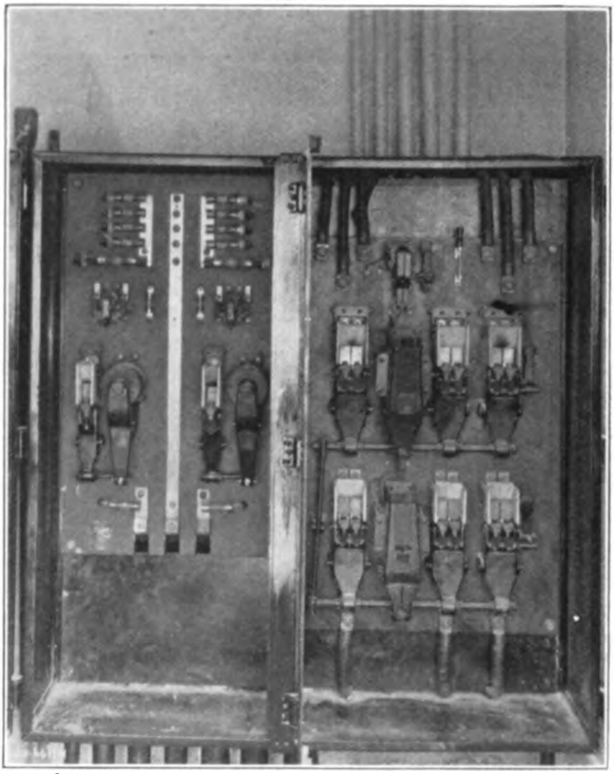
Special Service for Train Lighting and Train Battery Charging

For this purpose, two 50-KW., Allis-Chalmers Mfg. Co.'s motor generators are installed in the substation and controlled from the main switchboard. The motors are 230-volt D. C. The generators are designed to operate from 70 V. to 90 V. The remote control starting panels for these sets were furnished by the Sundh Electric Co., and equipped with "Urelite" I. T. E. enclosed, externally operated circuit breakers.

Three classes of service are handled from this system. Some of the trains



VIEW OF THE MAIN WAITING ROOM AND ONE OF THE TORCHERES FOR LIGHTING THE SIDE WALLS.—LEFT, THE IMPRESSIVE COLONNADE ALONG CANAL STREET.



EMERGENCY AUTOMATIC TRANSFER PANEL.

entering the station are lighted by a steam-turbine-driven generator in the baggage car using steam from the locomotive. This is called the head end system. If a train is set in the station without the locomotive, it is necessary to provide another source of current for lighting the train. This requires a 64-V. constant potential. For this service a receptacle is provided at each bumping post, which is fed by two circuits from this section of the main switchboard.

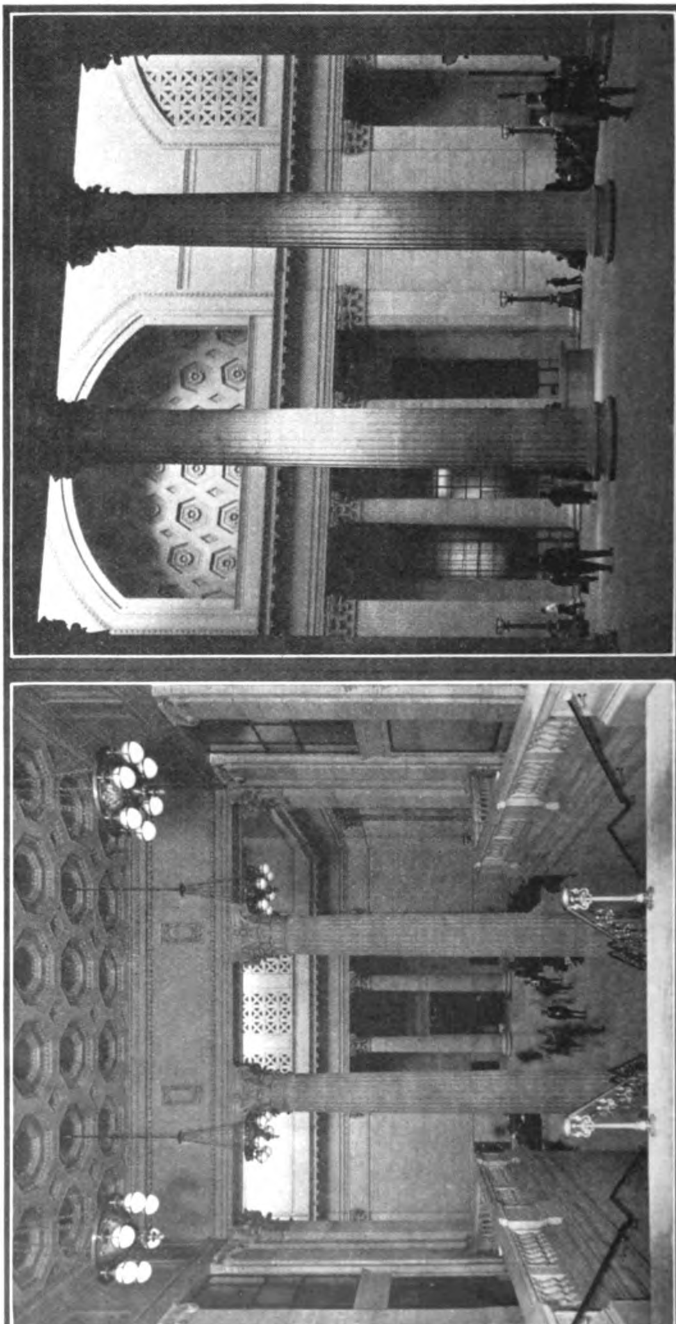
Some of the trains entering the station have axle-driven generators and batteries on each car. Part of these are 32 V. and part 64 V.

The charging of these batteries is generally done in the railroad yards. It may be necessary at times, however, to charge these batteries in the station. To provide for this, receptacles are installed along the platforms for each track at intervals of approximately 250 feet. These receptacles for the south bound tracks are fed from a similar system in the Mail Terminal substation. Those for the north bound tracks are fed from this substation.

Six circuits supply these receptacles through Allen Bradley Mfg. Co.'s rheostats and circuit breakers so that any desired charging rate can be supplied. Reverse current mechanisms on the breakers prevent discharge of battery in case of power failure.

These circuits are normally dead. If a car inspector wants to charge a battery, he calls the substation operator from phones located on platforms, giving him the receptacle number, battery voltage and rate desired. The operator then energizes the proper circuit and adjusts the charging rate by the carbon compression rheostats to the desired current.

When both head end lighting and 32-volt battery charging are required at the same time, the generator will be operated



LOOKING INTO THE MAIN WAITING ROOM FROM ONE OF THE CANAL ST. STAIR LOBBIES (LEFT) AND FROM THE TICKET OFFICE LOBBY (RIGHT).

at approximately 70 volts, which will give constant potential for the head end system and can be reduced to proper voltage by the rheostats for the 32-volt battery charging.

When it is necessary to supply the head end lighting and charge 64-volt batteries at the same time, the generator will be operated at approximately 90-V. to which the charging circuits will be connected through the rheostats, and a counter E. M. F. cell is connected in one side of the 90-volt bus ahead of the head-end lighting circuits. This cell will give a fixed drop of about 20 volts regardless of amount of current passing through it. This provides the constant potential of approximately 70 volts for the head end system. This cell is cut in or out by means of a single-pole, double-throw switch on switchboard. The resistances are so designed that 32-volt batteries can also be charged from the 90-volt bus if necessary to charge both at the same time.

Motor and Control Equipment

The demand for a wide range of speed for a very large percentage of the motors determined the installation of a direct current power system. The control equipment throughout was manufactured by the Sundh Electric Co., and comprises a variety of types, including automatic, remote control and hand starters. All starters are enclosed in steel cabinets. Hand starters under 25 hp., are of the sliding contact type. Those of 25 hp. and over are of the butt type, the contacts being operated by cams on a shaft which extends through the end of the cabinet to which the handle is connected. Mounted directly above each starter and on the same panel is a "Urelite" enclosed, externally operated, overload breaker manufactured by the Cutter Electrical & Mfg. Co.

Where there are two or more motors controlled by one automatic panel, a dial switch is provided so that any motor desired will start first.

A very special controller is provided for the pneumatic tube system blowers. When one of these motors approaches full load the second machine cuts in automatically. Relays are provided to cancel the idling current of the second motor

LEFT—A VIEW OF THE WELL LIGHTED TRAIN CONCOURSE. RIGHT—RAMPS LEADING FROM PLATFORMS. PASSENGER RAMPS LEAD UP TO THE CONCOURSE. ENCLOSED BAGGAGE RAMPS LEAD DOWN TO THE BAGGAGE ROOM.

so that it will cut out again automatically when load can be carried by one motor.

The fire pump is located in the room adjoining the substation. It has a 250-hp., 3-phase, 440-volt, Westinghouse motor with a Sundh Electric Co. hand or automatic starter.

Various Types of Lighting Service Installed

The main waiting room has a skylight, the highest point of which is 112 feet above the floor. There are two balconies, one at each end of the room, which are 49 feet above the floor. To illuminate the walls of the waiting room above the cornices and up to the skylight, two flood lighting banks have been installed (one bank on each balcony.) Each bank contains 35 750-Watt "X-Ray" projectors to illuminate the opposite half of the room. These flood lighting banks are remote controlled from buttons located in a cabinet near the corner of the ticket office, this same cabinet controlling all the lights in the public spaces in the Headhouse.

Heavy ornamental bronze torcheres or lighting standards mounted on marble bases are located along the wall of the main floor of the waiting room. There are 16 of these installed. There are several interesting features in connection with the construction of these lamps.

These standards set very close to the wall and are intended to light the under side of the cornice and the wall below the cornice. To distribute the light evenly over the wall a special reflector is placed in the top of the bowl. The top of this reflector is rectangular with the sides sloped and curved to give the desired distribution. To provide even distribution of light on the walls a set of sheet metal louvers is installed in the top of the reflector, parallel with the wall. The top is enclosed with a flat Pyrex glass, sand-blasted to obtain diffusion, which serves as a dust cover. There are two 250-watt flood light lamps in the reflector and four 100-W. lamps below the reflector to illuminate the bowl.

In the niche in the west wall above the cornice a bank of 18 lights has been installed in a trough reflector to light this space to the same intensity as the side walls and smooth out the shadows cast by the flood lights.

The Ticket Lobby Passage adjoining the east side of the Waiting Room has an arched ceiling the highest point of which is 80 feet above the floor. Along the north and south sides of this is an ornamental cornice the same height as the cornice in the waiting room. Twenty-four 100-watt X-Ray projectors are installed on each side of the cornice to light the ceiling. There are also four ornamental bronze brackets installed on each side about 15 feet above the floor.

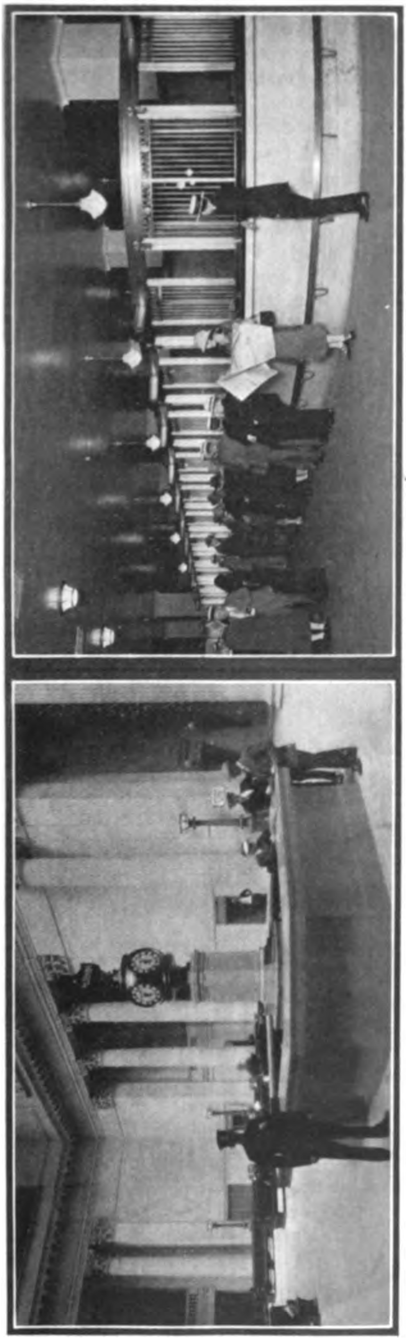
Ornamental bronze ceiling fixtures are used in the lobbies adjoining the main waiting room, in the women's waiting room and in the restaurant. Special fixtures of artistic design are used in the main dining room. In the main concourse a rather simple design of fixture is installed. Twelve opal glass globes are hung from a steel tube ring which in turn is supported by chains. All overhead lighting fixtures which are mounted extremely high and in inaccessible places have a special lowering arrangement to permit cleaning.

Trainshed Lighting

Special 200-watt lighting units were designed for the passenger platforms. The corrosive action of the air and gases to which these will be exposed lead to a very sturdy but simple construction with a very few small parts. The general construction is that of a street light or outdoor fixture, having a metal top with enclosing globe. The hood and glass holder are partly made of cast aluminum and partly of Major metal, a special non-corrosive aluminum alloy. The glassware is a lightly flashed ripple glass of acorn shape. The holder is clamped to the hood by two large thumb screws and is provided with a hook to swing on when open. A heavy wool felt gasket is used to make the unit as nearly air and dust tight as possible. The inside of the hood is polished to provide a reflecting surface. These fixtures were manufactured by the A. V. Boetter Mfg. Co.

For the baggage platforms an enameled steel reflector was used. It has the standard R. L. M. shape and is provided with a clear Pyrex glass cover to make it air and dust tight. These were furnished by the Wheeler Reflector Co.

There are a total of 1000 lighting units



VIEW IN THE MAIN WAITING ROOM SHOWING THE INFORMATION COUNTER AND AT THE RIGHT THE TICKET OFFICES WHICH ARE UNDER CANAL STREET.

in the trainshed, all of the 200-watt size. The spacing is about 21 feet and the height about 21 feet. The trainshed lights are fed from transformers located in vaults under the baggage platforms. There are two vaults in the north sheds and two in the south trainsheds.

Two 25-KVA distribution transformers are installed in each vault. The two 2300-volt trainshed lighting feeders mentioned above are each connected to one transformer in each vault. The transformer secondaries are connected for three-wire, 115/230-volt service. The circuits are also three-wire. Panel boards are installed in each vault with a Sundh Bull. No. 6000 remote control switch for each circuit.

The control buttons are located at the train gates for both baggage and passenger platforms. The baggage platform lights can also be controlled from the baggage room at the foot of the ramps.

Each platform is controlled separately by four switches. Two switches control alternate lights over one-half the length of the platform and similarly two switches control the other half. This provides a very flexible control of the lighting. The two transformers in each vault feed alternate lights in its section of the sheds. If one transformer should fail there will still be alternate lights over the entire section fed from that vault. If one of the 2300-volt feeders should fail, alternate lights will still be in service over the entire trainsheds.

Office Lighting

The ceiling fixtures in the offices are uniform throughout the building. They are a semi-indirect lighting unit of special design and furnished by the Central Electric Co. The bowls are their standard "Attalite" shape but blown in clear glass instead of opal. The lower part is heavily enameled to reduce the brightness and also to reflect the light to the ceiling. The top of the bowl is lightly enameled to give the necessary diffusion. The bowl is supported by a brass stem with one link just below the canopy. The globe holder is fitted with a glass neck which is enameled to the same density as the top of the bowl. This permits the light, which is cut off by the ordinary holder, to reach the ceiling. Three

hundred watt lamps are used in a large part of these fixtures. There are a few 200-W. and 500-W. lamps used. A very comfortable and well diffused lighting is obtained from these fixtures with an illumination intensity of from 7 to 8 foot-candles. Even distribution was difficult to obtain on account of the low mounting heights of some floors, the wide spacing and the large lamps required, the spacing being 14 feet to 15 feet and the height 8 feet. Two lights are installed in each bay.

Each bay is wired separately and has one circuit. Circuits are run from the cutout cabinet to base outlets on columns on the permanent wall, then to the switch outlet directly above base outlet, thence to outlet boxes at ceiling line. Conduit is used for this portion of the run. From the outlet box at the ceiling oval duct is run on face of tile to the ceiling outlets. This arrangement provides a very flexible means for rearrangement of lights and subdividing of space.

SWITCHBOARD FOR HANDLING ALL RESERVATIONS FOR SLEEPING AND PARLOR CARS.

Special Street Lighting Installation

Heavy bronze lighting standards at the Adams Street and Jackson Boulevard entrances add to the rugged and massive architectural treatment of the Headhouse. The street lighting standards support two G. E. "Novalux" standard basket type street lighting units each with 600-candle-power lamps. The two lamps are in series in the secondary circuit of a series street lighting transformer mounted in the base of the standard. The filaments in these lamps are 15.5-volt, 20-amp. type, which are more rugged than the 6.6 amp. street lighting lamps. There are 40 ornamental street lighting standards arranged on two circuits with primaries of the transformers regulated for a constant current of 6.6 amp. Along the river drive six stone standards of pyramid form are equipped with four 100-candle power, 6.6-amp. lamps. The same transformer arrangement is used on these standards as on the street lighting standards.

The standards are arranged for combination trolley and light poles. An extra heavy steel pole in four sections—8 in., 7 in., 6 in., and 5 in.—forms the center and main support and is set in a heavy steel casting mounted in the sidewalk structure. The ornamental cast iron portion is mounted in sections around the trolley pole with provision for movement of pole on account of trolley suspension.

Emergency Lighting System

An emergency lighting system, independent of the regular lighting feeders has been installed throughout the station.

To this system are connected the exit lights, fire escape lights, stair lights and scattered lights throughout the public spaces. This system will normally be fed from the lighting section of the main switchboard in the substation. In case of failure of this regular service, it will

be automatically thrown over to an emergency feeder from the Commonwealth Edison Co. direct current system. It is switched back automatically to the regular service when it is restored.

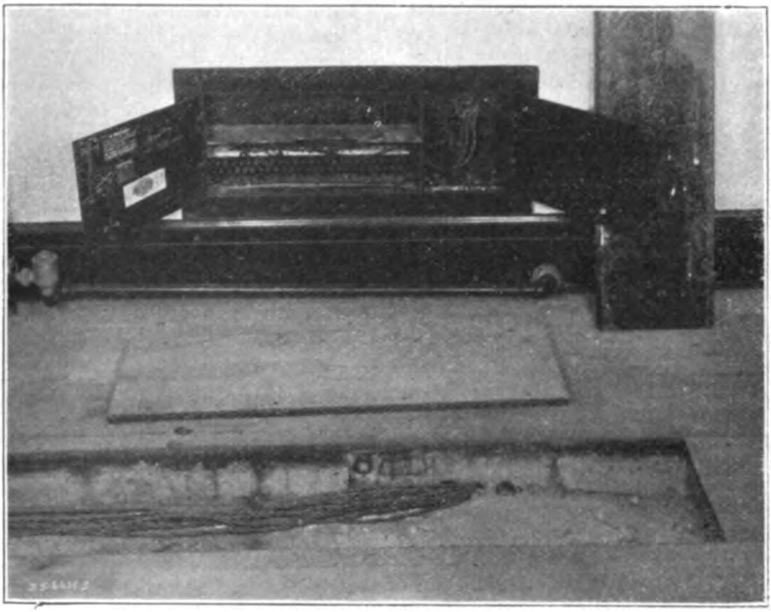
This will provide sufficient lighting in all public spaces to prevent accident if regular lighting should fail.

Telephone System

An automatic telephone system has been installed by the Illinois Bell Telephone Co., covering the entire property. A two position semi-mechanical switchboard has been installed with trunk lines connecting to the State exchange. This is called the General Office board There are also private lines connecting it with the Consolidated Ticket Offices and the railroad general office boards. All calls between local phones are made automatically, by dialing three digits. Outgoing city calls are made automatically, but incoming calls are handled by the operator at the switchboard. The switchboard and automatic squipment are located on the 3rd floor of the main building.

The telephone information board is a mechanical board with trunk lines connecting it to the Franklin exchange and private lines connecting it with the above board, the railroad offices and the Public Reservation Board. It has twelve positions, six on each side, with all lines multipled through so that all lines appear in each position. On the top of this table and along each side at the back of the operators are racks with sloping glass tops for time tables, rate information, etc. This board is also located on the 3rd floor.

The sleeping and parlor car reservations are handled by two switchboards in a separate room adjacent to the information room. There are two switchboards in this room. One of them has connections only with the ticket sellers, located in the Station Ticket Offices, the Consolidated Ticket Offices and the Hotel Ticket Offices. This has 28 positions, 14 on each side. This has automatic equipment, and the ticket seller gets any position he wants by dialing one digit. All of the diagrams for the four railroads entering the station are kept in a pigeonhole rack mounted on the center of the board.



TELEPHONE TERMINAL CABINET AND FLOOR TRENCH (UNCOVERED) IN FOREGROUND.

Along one side of this board is a 10-position board. This handles all public calls for reservation. It has lines connecting it with the Information Board and the Station General Office board and can be reached by calling either of these boards.

Telephone service is also provided for the observation cars while standing in the Station. A receptacle is installed at each bumping post. Cords and plugs are provided for connecting the phones in the cars to these receptacles. Each receptacle has a separate line to the general office switchboard. Calls can be made or received in the observation cars the same as at any other phone connected to the general office board.

Many special and interesting features have been worked out in this telephone installation, some of which were thought impossible, when first suggested to the Telephone Company's engineers, who deserve the credit for the success of the system.

Wire Distribution

Telephone and low voltage wires are distributed throughout the offices in trenches that run below the wood floor along the outside and inside walls of the building. These trenches are 8 in. wide and about 3 in. deep and run through every office in the building. Conduits leading from the four vertical risers near each corner of the building lead to the trench system. About every 50 or 60 feet along the wall there is a steel terminal cabinet located just above the base board with conduit connections to the main trench in which the telephone company has terminated a 25-pair cable. In addition to the main system of trenches each bay has three small trenches about 2 in. x 3½ in. running between the corridor and the main trench. This arrangement permits desks to be located anywhere in an office, allowing telephone or signal wires to be fished through the floor by drilling a hole through wood floor into the lateral trench. The main trench is accessible by removing the floor in sections about 5 ft. in length.* Telephone connection is made by fishing twisted pairs from the lateral trench into the main trench and then to the nearest terminal cabinet. All wires in the trench are in lead cable with the exception of the twisted pairs from the terminal cabinet to the desk phones.

At the south end of the sub-basement is a cable vault which has underground duct connections to the street, the four riser shafts in the main building, various terminals in the concourse and the entire length of the property. Immediately above this vault is a mezzanine floor with separate room for each utility for its terminal racks. All telephone, telegraph, special railroad wires and low tension services enter the building and are distributed by this system.

Telautograph System

Information regarding train movements is handled by telautographs or electric writing machines. There are sending and receiving stations in the north and south signal towers and in the telegraph office. Receiving stations are located at various points throughout the building, where information concerning the arrival and departure of trains is important. Some of the receiving station locations are as follows: North cab office, information desks in the concourse and waiting room, ticket office, station master's office, passenger agent's office, baggage checking counter, basement baggage room, mail room, telephone information bureau and the Mail Terminal building.

Electric Clocks, Time Stamps and Time Recorders

The clock system is a combination of self-winding, primary and secondary clocks. There are approximately 75 secondary units and two self-winding control clocks. The latter are used for operating the secondary clocks, time stamps and time recorders. One of these is the Master Clock, located in the station telegraph office in plain sight of the operator and train crews. It is kept to correct time by comparison with U. S. Observatory time signals received daily in the telegraph office. This clock synchronizes an auxiliary control clock once each hour. The secondary clocks are of the half-minute impulse type.

The distributing apparatus is located in the substation and is operated by a 30-volt, 120-amp.-hour Electric Storage Battery Co.'s battery. The distributing panel is equipped with two extra large

platinum point relays. One of these operates six circuits of clocks and the other four circuits. They are equipped with the usual switches, strap keys, fuses, etc., for individual control of the various circuits. Each circuit has a pilot clock on the control panel. It is a multiple operation system. The secondary clocks are all of the half minute impulse type and are of three sizes according to the diameter of the dials. All exterior clocks are provided with an outside glass cover to protect the hands from the weather.

The magnets are specially wound so that the consumption of current is reduced to the minimum.

The battery is automatically charged throught the medium of Tungar rectifier which is floated across the battery giving a charge of from 1½ Amp. to 2 Amp.

The clocks in the public spaces are illuminated by interior lights.

Typical office clocks are installed in the various work rooms and offices. All public clocks are of special design with one, two or four dials as required in handsome bronze cases.

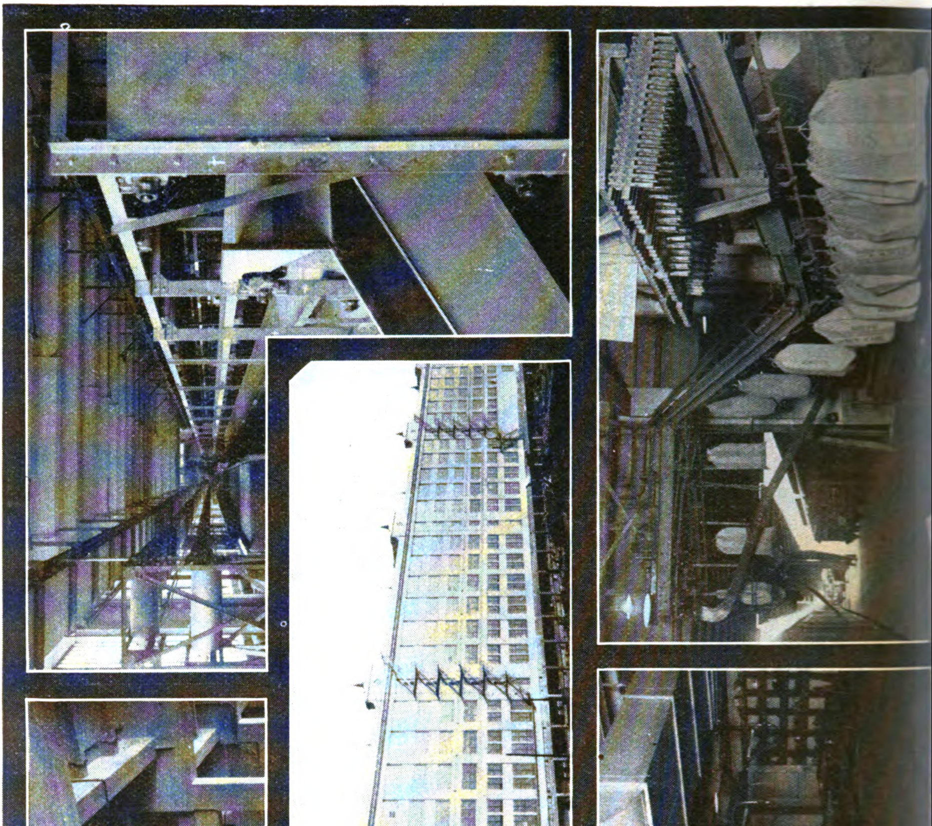
While the half minute impulse type clock records time sufficiently accurate for ordinary purposes, it is essential that clocks for telegraph and dispatchers offices record seconds. For this purpose self-winding clocks of the pendulum type are used. A special contact is used for synchronizing these clocks which receive the hourly signals from the Master Clock.

The time stamp and time recorder system has its own control panel with relays, strap keys, fuses, switches, etc., for seven circuits and is operated by the same Master Clock as the clock system. These are of the minute impulse type. This equipment was furnished by the Stromberg Electric Co.

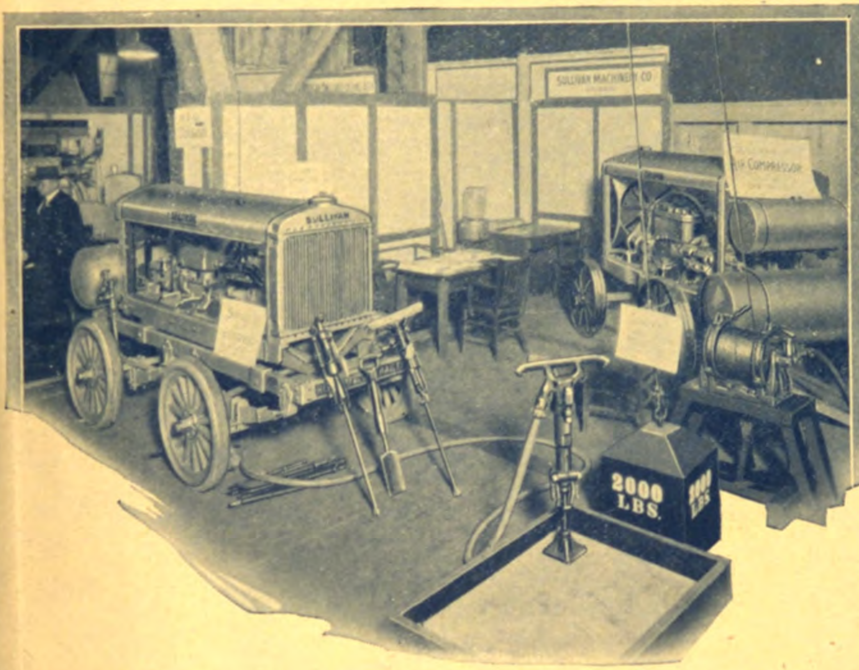
The clocks were all furnished by the Self Winding Clock Co., and the whole system installed by them.

All bronze cases were furnished by A. E. Coleman.

The Society is indebted to **The Railway Age** for the use of a number of the illustrations in this and the November issues of the Journal.



THE MAIL TERMINAL AND SOME VIEWS OF THE SPIRAL CHUTES, CONVEYORS, DISTRIBUTING SYSTEM AND CHARGING STATION FOR TRACTORS.



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